Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant) 2004

City of San Diego

Ocean Monitoring Program

Metropolitan Wastewater Department

Environmental Monitoring and Technical Services Division

July 1, 2005

THE CITY OF SAN DIEGO

Mr. John Robertus
Executive Officer
Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123

Attention: POTW Compliance Unit

Dear Sir:

Enclosed is the 2004 Annual Receiving Waters Monitoring Report for NPDES Permit No. CA0109045, Order No. 2000-129, for the City of San Diego South Bay Water Reclamation Plant (SBWRP) discharge to the Pacific Ocean through the South Bay Ocean Outfall. This report contains data summaries and statistical analyses for the various portions of the ocean monitoring program, including oceanographic conditions, microbiology, sediment characteristics, macrobenthic communities, demersal fishes and megabenthic invertebrates, and bioaccumulation of contaminants in fish tissues. These data are also presented in the International Boundary and Water Commission's annual report for discharge from the International Wastewater Treatment Plant (NPDES Permit No. CA0108928, Order No. 96-50).

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, I certify that the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,

ALAN C. LANGWORTHY
Deputy Metropolitan Wastewater Director

ag

Enclosure

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Acknowledgments: We are grateful to the personnel of the City's Marine Biology Laboratory for their assistance in the collection and processing of all samples and for discussions of the results. The completion of this report would not have been possible without their continued efforts and contributions. We would also like to acknowledge the City's Microbiology and Chemistry laboratories for providing the bacteriological and chemistry data analyzed herein. Reviews of the various chapters were provided by R. Gartman, A. Groce, N. Haring, D. Ituarte, D. O'Donohue, D. Olson, L. Othman, T. Stebbins, and R. Velarde.

Cover photo: *Platymera gaudichaudii* (Crustacea: Calappidae), by Kelvin Barwick.

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How to cite this document: City of San Diego. 2005. Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant) 2004. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

Executive Summary

The ocean monitoring program for the South Bay Ocean Outfall (SBOO) is conducted in accordance with NPDES permit requirements for the International Wastewater Treatment Plant (IWTP) operated by the International Boundary and Water Commission and the South Bay Water Reclamation Plant (SBWRP) operated by the City of San Diego.[1] These documents specify the terms and conditions that allow treated effluent originating from the IWTP and SBWRP to be discharged into the Pacific Ocean via the SBOO. In addition, the Monitoring and Reporting Programs contained within each permit define the requirements for monitoring the receiving waters environment, including sampling plans, compliance criteria, laboratory methods, data analysis and reporting guidelines.

The main objectives of the South Bay monitoring program are to provide data that satisfy the requirements of the NPDES permits, demonstrate compliance with the 2001 California Ocean Plan (COP), monitor dispersion of the waste field, and identify environmental changes that may be associated with wastewater discharge. Specifically, the program is designed to assess the impact of wastewater on the marine environment off southern San Diego, including the effects on water quality, sediment conditions, and the marine biota. The study area centers around the SBOO discharge site, which is located approximately 5.6 km offshore at a depth of about 27 m. Monitoring at sites along the shore extends from Coronado southward to Playa Blanca, Mexico. Offshore monitoring is conducted in an adjacent area overlying the coastal continental shelf at sites ranging in depth from about 9–55 m.

Prior to the initiation of wastewater discharge from the IWTP in 1999, the City of San Diego conducted a 3½-year baseline study designed to characterize background environmental conditions in the South Bay region in order to provide information against which post-discharge data could be compared. Additionally, a region-wide survey of benthic conditions is typically conducted each year at randomly selected sites from about Del Mar to the US/Mexico border as part of the NPDES permit requirements. Such studies are useful for evaluating patterns and trends over a broader geographic area, thus providing additional information to help distinguish reference areas from sites impacted by anthropogenic influences.

The receiving waters monitoring effort for the South Bay region may be divided into several major components, each comprising a separate chapter in this report: Oceanographic Conditions, Microbiology, Sediment Characteristics, Macrobenthic Communities, Demersal fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Data regarding various physical and chemical oceanographic parameters are evaluated to characterize water mass transport potential in the region. Water quality monitoring along the shore and in offshore waters includes the measurement of bacteriological indicators to assess both natural (e.g., river and streams) and anthropogenic (e.g., storm water and wastewater) impacts. Benthic monitoring includes sampling and analyses of soft-bottom macrofaunal communities and their associated sediments, while communities of demersal fish and megabenthic invertebrates are the focus of trawling activities. The monitoring of fish populations is supplemented by bioaccumulation studies to determine whether or not contaminants are present in the tissues of "local" species. In addition to the above activities, the City, the International Boundary and Water Commission, and the San Diego Regional Water Quality Control Board (RWQCB) support other projects relevant to assessing ocean quality in the region. One

[1] IWTP (NPDES Permit No. CA0108928, Order No. 96-50); SBWRP (NPDES Permit No. CA0109045, Order No. 2000-129, Addendum No. 1)

such project is a remote sensing study of the San Diego/Tijuana coastal region, the results which are incorporated herein into the interpretations of oceanographic and microbiological data (see Chapters 2 and 3).

The present report focuses on the results of the ocean monitoring activities conducted in the South Bay region during calendar year 2004. An overview and summary of the main findings for each of the major components are included below. A separate regional benthic survey of randomly selected sites was not conducted during the summer of 2004 pursuant to an agreement with the RWQCB and USEPA to conduct a special study to generate scientifically defensible maps of sediment condition in the San Diego region (see Appendix A in City of San Diego 2005)[2]. The results of the "San Diego Sediment Mapping Study" are not yet available and are therefore not included herein.

OCEANOGRAPHIC CONDITIONS

Oceanographic conditions in the South Bay region were generally similar to previous observed seasonal patterns. Thermal stratification of the water column followed the typical cycle with maximum stratification in mid- to late summer and reduced stratification during winter. Surface temperatures were affected by drought conditions that persisted from January through mid-October resulting in an extended warming trend, which was more gradual, longer lasting, and yielded slightly warmer surface waters than in 2003. In contrast, water clarity was negatively impacted by record rainfall during February, late October, and December of 2004. These storms resulted in heavy runoff into nearshore waters, which subsequently resulted in persistent turbid conditions. For example, aerial imagery from the remote sensing study indicated that runoff from the Tijuana River was the most significant contributor to increased turbidity at these times. The input of freshwater associated with the increase in runoff likely contributed to reduced salinity values observed at the kelp stations during the spring and fall months. In general, data from both oceanographic measurements and aerial imagery provide no evidence of change in any water quality parameters (e.g., dissolved oxygen, pH) that can be attributed to wastewater discharge from the SBOO.

MICROBIOLOGY

The greatest effects on nearshore water quality conditions in the South Bay in 2004 appeared to be associated with a) the above average rainfall during February, October, and December, and b) the northward current flow that occurred during April and October–December. For example, during these periods, runoff from the Tijuana River along with discharge from the Los Buenos Creek was carried northward into the sampling grid. The elevated bacterial densities associated with these water masses contributed to the lowest overall rates of shore and kelp station compliance with COP standards since January 1999, when calculations became required after the onset of discharge. Data from monthly offshore monitoring sites suggested that the wastewater plume was confined below a stratified water column from April through October. Bacterial counts indicative of wastewater were evident in surface waters only during January, March, and December when the water column was well mixed. Overall, data from shore, kelp, and monthly water quality stations suggest that elevated bacterial counts detected along the shore in 2004 were not caused by the shoreward transport of the SBOO wastewater plume. Instead, the distribution and frequency of high bacterial counts in nearshore waters correspond to inputs from the Tijuana River and the northward transport of materials

[2] City of San Diego. (2005). EMTS Division Laboratory Quality Assurance Report, 2004. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

from the river and Los Buenos Creek, particularly during the rainy season.

SEDIMENT QUALITY

The composition and quality of ocean sediments in the South Bay area were similar in 2004 to those observed during previous years. Sediments at most sites were dominated by fine sands with grain size tending to increase with depth. Stations located offshore and southward of the SBOO discharge area consisted of very coarse sediments, while sites located in shallower water and north of the outfall towards the mouth of San Diego Bay had finer sediments. Spatial differences in sediment composition can be partly attributed to patches of sediments associated with different origins (e.g., relict red sands, other detrital material). For example, the deposition of sediments from the Tijuana River and to a lesser extent from San Diego Bay probably contributes to the higher content of silt at nearby stations.

As in previous years, there was no evidence that discharged wastewater from the SBOO negatively impacted contaminant concentrations in South Bay area sediments. Concentrations of organic indicators such as total organic carbon, total nitrogen and sulfides, as well as various trace metals were generally low in South Bay sediments relative to other coastal areas off southern California. In general, the highest organic indicator and metal concentrations were associated with finer sediments. In addition, other contaminants (e.g., pesticides, PAHs) were detected infrequently or at low levels. For example, derivatives of the pesticide DDT were found in sediment samples from only three sites in 2004; the presence of DDT does not appear to be related to wastewater discharge since it was present at these sites prior to outfall construction. In addition, although PAH compounds were detected more frequently in 2004 than in previous years, this was due to a change in reporting procedures. PAH concentrations were very low overall and unlikely related to wastewater discharge. Finally, PCBs were not detected in sediments from any station in 2004.

MACROBENTHIC INVERTEBRATE COMMUNITIES

Benthic communities in the SBOO region included macrofaunal assemblages that varied along gradients of sediment structure (e.g., grain size) and depth (e.g., shallow vs. mid-depth waters). During 2004, assemblages surrounding the SBOO were similar to those that occurred during previous years. Most sites were dominated by the spionid polychaete *Spiophanes bombyx*, a species characteristic of other shallow-water assemblages in the Southern California Bight. Another type of assemblage occurred in slightly deeper waters at sites where the sediments contained finer particles. Although this assemblage was also dominated by *S. bombyx*, it was distinguished from the shallow-water assemblage by populations of the polychaetes *Chloeia pinnata*, *Myriochele gracilis*, and *Sthenelanella uniformis*, and probably represents a transition between assemblages occurring in shallow sandy habitats and those occurring in finer mid-depth sediments off southern California. Finally, sites with sediments composed of relict red sands were also characterized by unique assemblages.

Patterns of species richness and abundance also varied with depth and sediment type in the region, although there were no clear patterns with respect to the outfall. The range of values for most community parameters in 2004 was similar to that seen in previous years, and values of environmental disturbance indices such as the BRI and ITI were characteristic of undisturbed sediments. In addition, changes in benthic community structure near the SBOO that occurred in 2004 were similar in magnitude to those that have occurred previously and elsewhere off southern California. Such changes often correspond to large-scale oceanographic processes or other natural events. Overall, benthic assemblages in the region remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf. The data from present monitoring efforts provide no evidence that the SBOO wastewater discharge has caused any substantial degradation of the benthos in the area.

DEMERSAL FISH AND MEGABENTHIC INVERTEBRATE COMMUNITIES

As in previous years, speckled sanddabs continued to dominate fish assemblages surrounding the SBOO in 2004. This species occurred at all stations and accounted for 84% of the total catch. Other characteristic, but less abundant, species included the California lizardfish, roughback sculpin, hornyhead turbot, longfin sanddab, and yellowchin sculpin. Most of these common fishes were relatively small, averaging less than 17 cm in length. Although the composition and structure of the fish assemblages varied among stations, these differences were mostly due to variations in speckled sanddab populations.

Assemblages of relatively large (megabenthic) trawl-caught invertebrates were similarly dominated by a few, prominent species. The sea star *Astropecten verrilli* was the most abundant species, while the shrimp *Crangon nigromaculata,* and the crabs *Pyromaia tuberculata* and *Cancer gracilis* were also common. Although megabenthic community structure also varied between sites, these assemblages were generally characterized by low species richness, abundance, biomass and diversity.

Overall, results of the trawl surveys conducted in 2004 provide no evidence that the discharge of wastewater has affected either fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance and distribution of species were similar at stations located near the outfall and further away. Finally, the absence of any physical abnormalities or evidence of disease on local fishes suggests that their populations remain healthy in the region.

TISSUE CONTAMINANTS IN FISHES

There was no clear evidence to suggest that tissue contaminant loads were affected by the discharge of wastewater from the SBOO in 2004. Although various contaminants were detected in both liver and muscle tissues, concentrations of most contaminants were not substantially different from those reported prior to discharge. In addition, samples of muscle tissues from sport fish collected in the area were found to be within FDA human consumption limits for both mercury and DDT.

The occurrence of both metals and chlorinated hydrocarbons in the tissues of South Bay fishes may be due to many factors, including the ubiquitous distribution of many contaminants in coastal sediments off southern California. Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species. Exposure to contaminants can vary greatly between species and even among individuals of the same species depending on migration habits. For example, fish may be exposed to pollutants in a highly contaminated area and then move into a region that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many other point and non-point sources that may contribute to contamination in the region.

Chapter 1. General Introduction

INTRODUCTION

The South Bay Ocean Outfall (SBOO) discharges treated effluent originating from two sources: the International Boundary and Water Commission's (IBWC) International Wastewater Treatment Plant (IWTP), and the City of San Diego's South Bay Water Reclamation Plant (SBWRP). Discharge from the IWTP began on January 13, 1999 and is performed under the terms and conditions set forth in Order No. 96–50, National Pollutant Discharge Elimination System (NPDES) Permit No. CA0108928 and Cease and Desist Order No. 96–52. Discharge from the SBWRP began on May 6, 2002 and is performed under NPDES Permit No. CA0109045, Order No. 2000–129. These NPDES permits define the requirements for monitoring receiving waters around the SBOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines.

Receiving waters monitoring for the South Bay region with respect to the above referenced permits is performed by the City of San Diego. Prior to the initiation of discharge through the SBOO, the City conducted a 3½-year baseline monitoring program in order to characterize background environmental conditions surrounding the discharge site (City of San Diego 2000a). The results of this baseline study provide background information against which the post-discharge data may be compared. In addition, the City has conducted annual region-wide surveys off the coast of San Diego since 1994 (see City of San Diego 1999, 2000b, 2001, 2002, 2003). Such regional surveys are useful in characterizing the ecological health of diverse coastal areas and may help to identify and distinguish reference sites from those impacted by wastewater discharge, stormwater input or other sources of contamination.

Finally, the City of San Diego, the IBWC, and the San Diego Regional Water Quality Control Board (SDRWQCB) also contract with Ocean Imaging Corporation (Solana Beach, CA) to conduct an aerial/satellite remote sensing program for the San Diego/Tijuana region as part of the ocean monitoring programs for the Point Loma and South Bay areas. Imagery from satellite data and aerial sensors produces a synoptic look at surface water clarity that is not possible using shipboard sampling alone. The major limitation of aerial and satellite images, however, is that they only provide information about surface or near-surface waters (~0–15 m) without providing any direct information regarding the movements, color, or clarity of waters in deeper layers. In spite of these limitations, one objective of this multi-year project is to ascertain relationships between the various types of imagery data and field-collected data. With public health issues a paramount concern of ocean monitoring programs, any information that helps to provide a clearer and more complete picture of water conditions is beneficial to the general public as well as to program managers and researchers. Having access to a large-scale overview of surface waters within a few hours of image collection also has the potential to bring the monitoring program closer to real-time diagnosis of possible contamination conditions and add predictability to the impact that different oceanographic events (e.g., heavy rains) may have on shoreline water quality.

This report presents the results of monitoring conducted at fixed sites around the SBOO from January through December 2004. Results of the 2004 aerial/satellite remote sensing surveys have also been considered and integrated into interpretations of oceanographic and water quality data (e.g., microbiological, total suspended solids, oil and grease). Comparisons are also made to conditions during previous years in order to assess any outfall related changes that may have occurred (see City of San Diego 2000a, b, 2001, 2002, 2003, 2004). The major components of the monitoring program are covered in the following chapters: Oceanographic Conditions, Water Quality, Sediment Characteristics, Macrobenthic Communities, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Detailed information concerning station locations, sampling equipment, analytical techniques, and quality assurance procedures are included in the Environmental Monitoring and Technical Services Division Laboratory Quality Assurance Project Plan for the City's Ocean Monitoring Program (City of San Diego in prep). General and more specific details of these monitoring programs and sampling designs are given below and in subsequent chapters and appendices.

SBOO MONITORING

The South Bay Ocean Outfall is located just north of the border between the United States and Mexico. It terminates approximately 5.6 km offshore at a depth of about 27 m. Unlike other southern California outfalls that are located on the surface of the seabed, the SBOO pipeline begins as a tunnel on land and then continues under the seabed to a distance of about 4.3 km offshore. From there it connects to a vertical riser assembly that conveys effluent to a pipeline buried just beneath the surface of the seabed. This pipeline then splits into a Y shaped multiport diffuser system, with the two diffuser legs extending an additional 0.6 km to the north and south. The outfall was designed to discharge and disperse effluent via a total of 165 diffuser risers. These include one riser located at the center of the outfall diffusers and 82 others spaced along each of the diffuser legs. However, low flow since outfall operation began has required closure of all ports along the northern diffuser leg as well as many of those along the southern diffuser leg. These closures are necessary to maintain sufficient back pressure within the drop shaft so that the outfall can operate in accordance with the theoretical model. Consequently, discharge during 2004 and previous years has been generally limited to the distal end of the southern diffuser leg, with the exception of a few intermediate points at or near the center of the diffusers.

The regular SBOO sampling area extends from the tip of Point Loma southward to Playa Blanca, Mexico, and from the shoreline seaward to a depth of about 61 m. The offshore monitoring sites are arranged in a grid spanning the terminus of the outfall, and are monitored in accordance with NPDES permit requirements. Sampling at these fixed stations includes monthly seawater measurements of physical, chemical and bacteriological parameters in order to document water quality conditions in the area. Benthic sediment samples are collected semiannually to monitor macrofaunal communities and sediment conditions. Trawl surveys are performed quarterly to monitor communities of demersal fish and large, bottom-dwelling invertebrates. Additionally, analyses of fish tissues are performed semiannually to monitor levels of chemical constituents that may have ecological or human health implications.

RANDOM SAMPLE REGIONAL SURVEYS

In addition to the regular fixed grid monitoring centered around the SBOO, the City typically conducts a summer benthic survey of sites distributed throughout the entire San Diego region as part of the monitoring requirements for the South Bay outfall. These annual surveys are based on an array of stations randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. Surveys conducted in 1994, 1998, and 2003 involved other major southern California dischargers, were broader in scope, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, USA). Results of the 1994 and 1998 surveys are available in Bergen et al. (1998, 2001), Noblet et al. (2002), and Ranasinghe et al. (2003), while data from the 2003 survey are currently being analyzed. Random benthic surveys limited to just the San Diego region were conducted in 1995–1997 and 1999–2002 (see City of San Diego 1999, 2000b, 2001, 2002, 2003). Finally, no regional (random) survey was conducted in 2004 in exchange for participation in a special strategic process study pursuant to an agreement with the SDRWQCB and USEPA. This "sediment mapping study" was designed to develop an understanding of spatial variability of sediments in areas of special interest and establish maps of the spatial extent and magnitude of environmental conditions surrounding both the Point Loma and South Bay outfalls (see City of San Diego 2005, Appendix A). The results from Phase I of the sediment mapping study will not be available until 2006.

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Chapter 2. Oceanographic Conditions

INTRODUCTION

The fate of wastewater discharged into deep offshore waters is strongly determined by oceanographic conditions and other events that suppress or facilitate horizontal and vertical mixing. Consequently, measurements of physical and chemical parameters such as water temperature, salinity and density are important components of ocean monitoring programs because these properties determine water column mixing potential (Bowden 1975). Analysis of the spatial and temporal variability of these parameters as well as transmissivity, dissolved oxygen, pH, and chlorophyll may also elucidate patterns of water mass movement. Taken together, analysis of such measurements for the receiving waters surrounding the South Bay Ocean Outfall (SBOO) can help: (1) describe deviations from expected patterns, (2) reveal the impact of the wastewater plume relative to other inputs such as San Diego Bay and the Tijuana River, (3) determine the extent to which water mass movement or mixing affects the dispersion/dilution potential for discharged materials, and (4) demonstrate the influence of natural events such as storms or El Niño/La Niña oscillations. In addition, combining measurements of physical parameters with assessments of bacteriological concentrations (see Chapter 3) can provide further insight into the transport potential surrounding the SBOO throughout the year.

To assess possible impacts from the outfall discharge, the City of San Diego regularly monitors oceanographic conditions of the water column. Although, water quality in the South Bay region is naturally variable, it is also subject to various anthropogenic and natural sources of contamination such as discharge from the SBOO, San Diego Bay and the Tijuana River. This chapter describes the oceanographic conditions that occurred during 2004 and is referred to in subsequent chapters to explain patterns of bacteriological occurrence (see Chapter 3) or other effects of the SBOO discharge on the marine environment (see Chapters 4–7).

MATERIALS and METHODS

Field Sampling

Oceanographic measurements were collected at 40 fixed sampling sites located from 3.4 km to 14.6 km offshore (**Figure 2.1**). These stations form a grid encompassing an area of approximately 450 km^2 and were generally situated along 9, 19, 28, 38, and 55-m depth contours. Three of these stations (I25, I26, and I39) are considered kelp bed stations subject to the California Ocean Plan (COP) water contact standards. The three kelp stations were

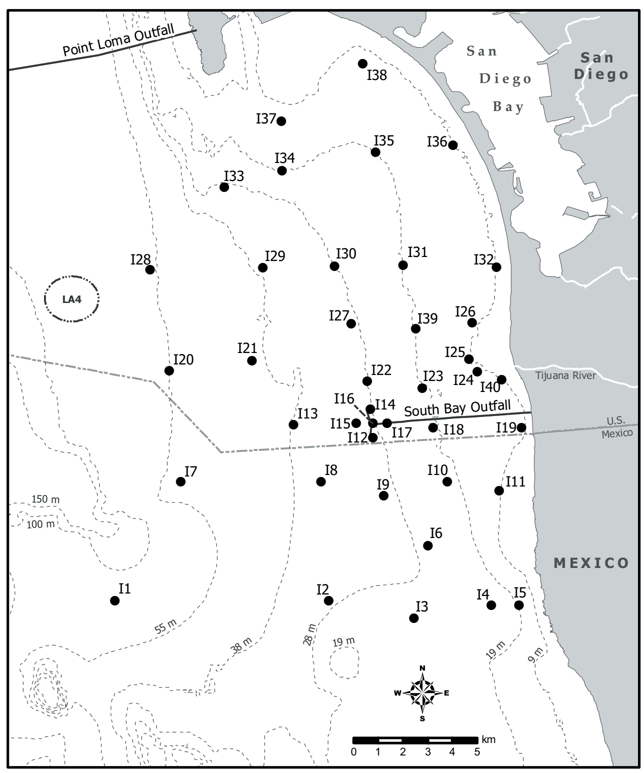

Figure 2.1
Water quality monitoring stations where CTD casts are taken, South Bay Ocean Outfall Monitoring Program.

selected for their proximity to suitable substrates for the Imperial Beach kelp bed; however, this kelp bed has been historically transient and inconsistent in terms of size and density (North 1991, North et al. 1993). Thus, these three stations are located in an area where kelp is only occasionally found.

Oceanographic measurements were collected at least once per month over a 3–5 day period. Values for temperature, salinity, density, pH, transmissivity (water clarity), chlorophyll *a*, and dissolved oxygen were recorded by lowering a SeaBird conductivity, temperature and depth (CTD) instrument through the water column. Profiles of each parameter were constructed for each station by averaging the values recorded over 1-m depth intervals during processing. This ensured that physical measurements used in subsequent data analyses corresponded with bacterial sampling depths. Further details regarding CTD data processing are provided in the City's Quality Assurance Plan (City of San Diego in prep.). To meet the COP sampling frequency requirements for kelp bed areas, CTD casts were conducted at the kelp stations an additional four times each month. Visual observations of weather and water conditions were recorded prior to each CTD sampling event.

Monitoring of the SBOO area and neighboring coastline also included satellite and aerial remote sensing performed by Ocean Imaging Corporation (OI). Satellite imagery included data collected from both Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat Thematic Mapper (TM) instrumentation. The aerial imaging was done using OI's DMSC-MKII digital multispectral sensor (DMSC). Its four channels were configured to a specific wavelength (color) combination, determined by OI's previous research, which maximizes the detection of the SBOO plume's turbidity signature, while also allowing separation between the outfall plume and coastal discharges and turbidity. The depth penetration of the imaging varies between 8 and 15 meters, depending on general water clarity. The spatial resolution of the data is usually 2 meters. Several aerial overflights were performed each month during the rainy season and a lesser number during the dry season.

RESULTS and DISCUSSION

Expected Seasonal Patterns of Physical and Chemical Parameters

Southern California weather can be classified into two basic "seasons", wet (winter) and dry (spring through fall), and certain patterns in oceanographic conditions track these "seasons." In the winters, water temperatures are cold and the water column is well-mixed resulting in similar properties throughout the water column. In contrast, dry summer weather warms the surface waters and introduces thermally-sustained stratification. Despite a sampling schedule that limits oceanographers to snapshots in time spread out over several days during each month, analyses of oceanographic data collected from the South Bay region over the past nine years support this pattern.

Each year, typical winter conditions are present in January and February. A high degree of homogeneity within the water column is the normal winter signature for all physical parameters, although storm water runoff may intermittently influence density profiles by causing a freshwater lens within nearshore surface waters. The chance that the wastewater plume may surface is highest during these winter months when there is little, if any, stratification of the water column.

Winter conditions often extend into March, when a decrease in the frequency of winter storms brings about the transition of seasons. The increasing elevation of the sun and lengthening days begin to warm the surface waters and cause the return of a seasonal thermocline and pycnocline to coastal and offshore waters. Once stratification is established by late spring, minimal mixing conditions tend to remain throughout the summer and early fall. In October or November, cooler weather, reduced solar input, and increased stormy weather cause

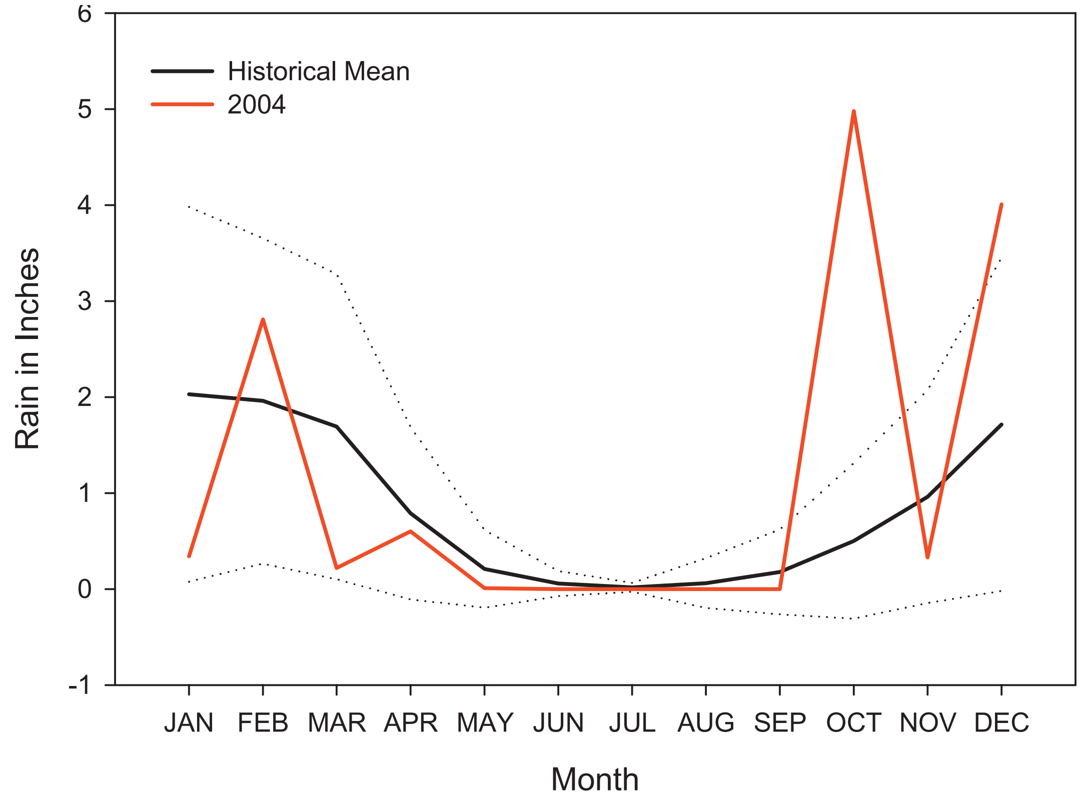

Figure 2.2
Total monthly rainfall at Lindbergh Field (San Diego, CA) for 2004 compared to monthly average rainfall (+/- 1 standard deviation) for the historical period 1914–2004.

the return of the well-mixed, homogeneous water column characteristic of winter months.

Observed Seasonal Patterns of Physical and Chemical Parameters

With the exception of greater than normal rainfall during February, drought conditions persisted from January through the first half of October in 2004 (**Figure 2.2**; NOAA/NWS 2005). Record rainfall occurred during the second half of October followed by below normal rainfall in November and then record rainfall again in December. Despite these circumstances, thermal patterns of the water column followed normal seasonal trends at the nearshore and offshore sampling areas (**Figures 2.3, 2.4**).

Temperature is the main factor affecting stratification of southern California ocean waters (Dailey et. al. 1993) and provides the best indication of the surfacing potential of the wastewater plume. During 2004, surface water temperatures ranged from 13.8 to 14.2°C in January–March. Seasonal warming of the surface water began in April, progressed gradually, and peaked in September when mean surface temperatures reached 22.2°C (**Table 2.1**). This pattern of a steady, gradual rise in surface temperatures was much different than in 2003, when temperature was more variable and peaked in July rather than September (City of San Diego 2004a). A relatively rapid decline in surface temperatures then occurred from September to October (~5°C) and from November to December (~2.5°C). In contrast, bottom temperatures were less variable, ranging from 10.3 to 14.4°C. Bottom temperatures decreased from 12.8°C in January to 10.3°C in June, and then gradually increased to 14.4°C by December. This pattern was generally similar to the previous year, although compared to 2003, 2004 bottom temperatures were 1–2°C cooler in January and February and about 1°C warmer in November and December.

Surface and mid-level water temperatures dipped several times during the year (i.e., May, July,

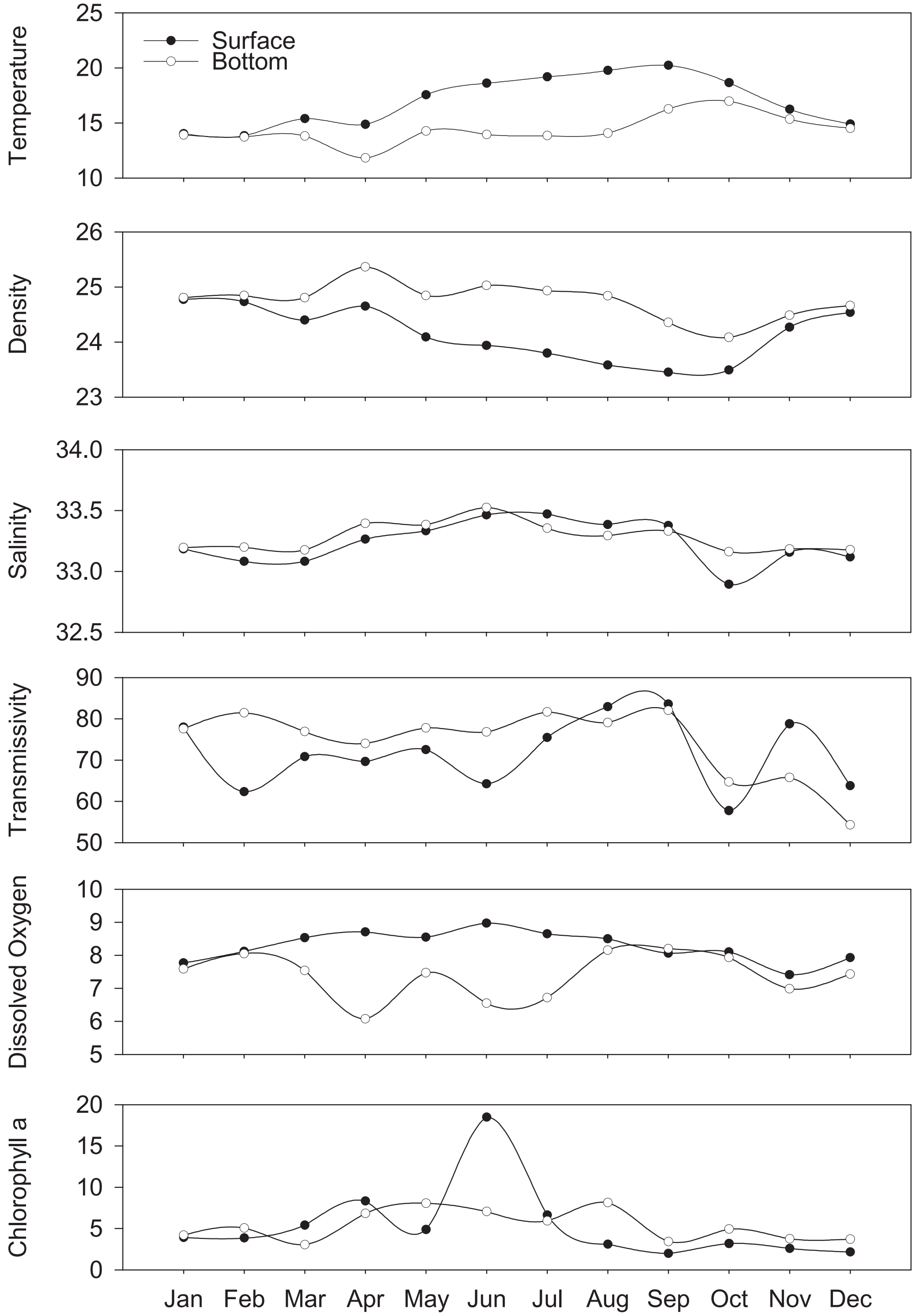

Figure 2.3

Monthly average temperature (°C), density (δ/θ), salinity (ppt), transmissivity (%), dissolved oxygen (mg/L), and chlorophyll *a* (µg/L) values for surface (≤ 2m) and bottom (≥ 18m) waters at the three kelp water quality stations during 2004.

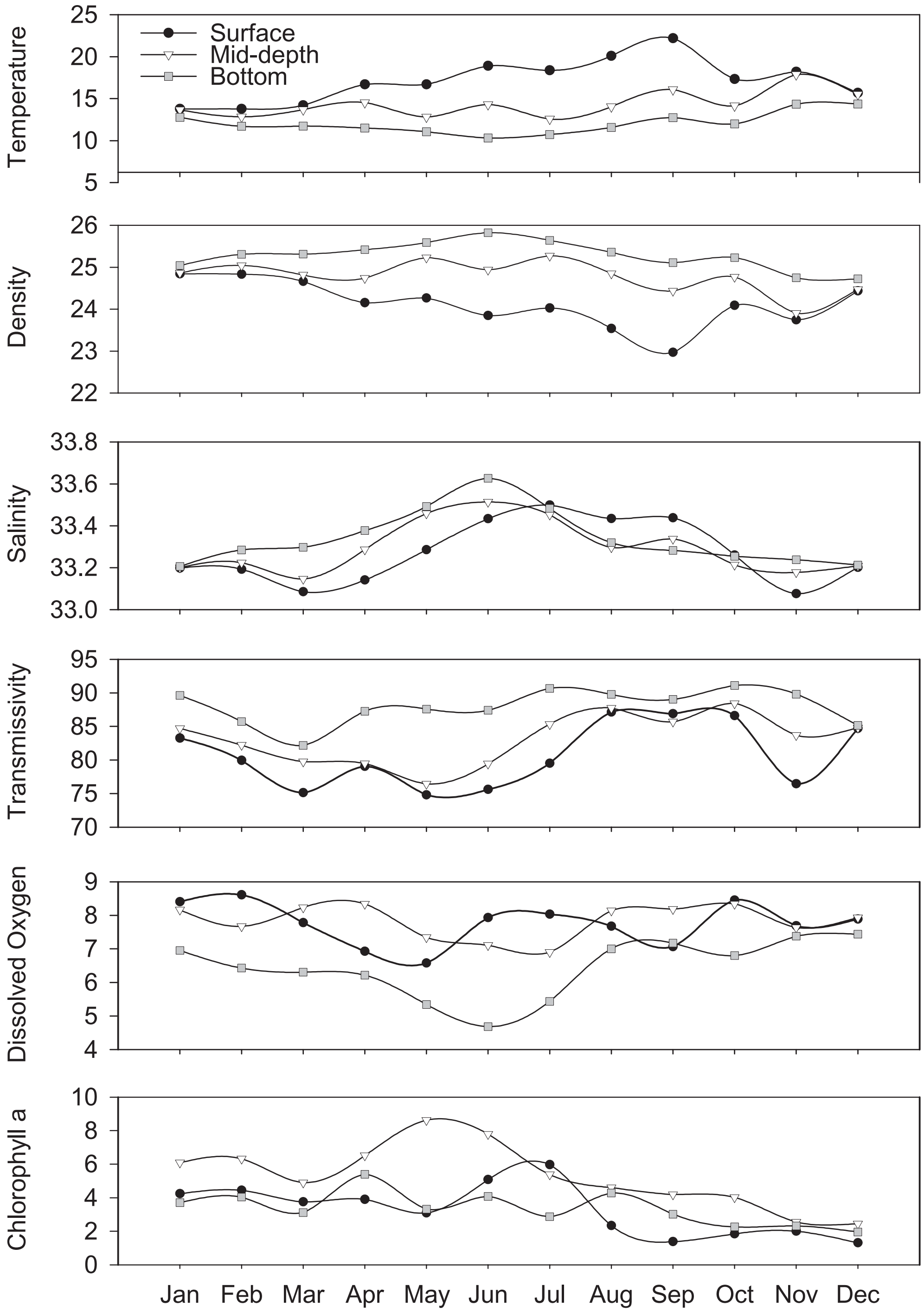

Figure 2.4

Monthly average temperature (°C), density (δ/θ), salinity (ppt), transmissivity (%), dissolved oxygen (mg/L), and chlorophyll *a* (µg/L) values for surface (≤ 2m), mid-depth (10–20m), and bottom (≥ 27m) waters at the monthly water quality stations during 2004.

Table 2.1

Differences between the top (≤2 m) and bottom (≥27 m) waters for mean values of temperature (°C), salinity (ppt), density (δ/θ), dissolved oxygen (mg/L), pH, chlorophyll *a* (µg/L), and transmissivity (%) at all SBOO stations during 2004. The greatest differences between top and bottom values are highlighted and in bold type.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature	*Surface*	13.8	13.8	14.2	16.7	16.7	18.9	18.4	20.1	22.2	17.4	18.2	15.7
	Bottom	12.8	11.7	11.7	11.5	11.1	10.3	10.7	11.6	12.7	12.0	14.3	14.4
	Difference	1.0	2.1	2.5	5.2	5.7	**8.6**	7.7	**8.5**	**9.5**	5.4	3.9	1.3
Density	*Surface*	24.84	24.83	24.66	24.16	24.26	23.85	24.03	23.54	22.97	24.09	23.75	24.44
	Bottom	25.04	25.31	25.32	25.42	25.59	25.83	25.64	25.36	25.11	25.23	24.75	24.72
	Difference	0.20	0.47	0.65	1.26	1.33	**1.98**	1.62	**1.82**	**2.14**	1.14	1.00	0.29
Salinity	*Surface*	33.20	33.19	33.09	33.14	33.29	33.43	33.50	33.44	33.44	33.26	33.08	33.20
	Bottom	33.21	33.28	33.30	33.38	33.49	33.63	33.48	33.32	33.28	33.25	33.24	33.21
	Difference	**-0.01**	-0.09	**-0.21**	**-0.24**	**-0.21**	-0.19	0.02	0.12	0.16	0.01	-0.16	-0.01
DO	*Surface*	8.4	8.6	7.8	6.9	6.6	7.9	8.0	7.7	7.1	8.5	7.7	7.9
	Bottom	7.0	6.4	6.3	6.2	5.3	4.7	5.4	7.0	7.2	6.8	7.4	7.4
	Difference	1.5	**2.2**	1.5	0.7	1.2	**3.3**	**2.6**	0.7	-0.1	1.7	0.3	0.5
pH	*Surface*	8.1	8.2	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.1	8.1	8.1
	Bottom	8.0	8.0	7.9	7.9	7.9	7.8	7.9	8.0	8.0	8.0	8.0	8.1
	Difference	0.1	0.2	0.2	**0.3**	**0.4**	**0.4**	0.3	0.2	0.2	0.2	0.1	0.0
XMS	*Surface*	83	80	75	79	75	76	80	87	87	87	76	85
	Bottom	90	86	82	87	88	87	91	90	89	91	90	85
	Difference	6	6	7	8	**13**	**12**	11	3	2	5	**13**	0
Chl a	*Surface*	4.2	4.4	3.7	3.9	3.1	5.1	6.0	2.3	1.4	1.8	2.0	1.3
	Bottom	3.7	4.0	3.1	5.4	3.3	4.1	2.9	4.3	3.0	2.3	2.3	2.0
	Difference	0.5	0.4	0.6	-1.5	-0.2	1.0	**3.1**	**-1.9**	**-1.6**	-0.4	-0.3	-0.6

October). These changes appeared to be the result of an influx of cold water as indicated by decreased temperatures and increased water density (Figures 2.2 and 2.3). Aerial imagery suggested several upwelling events occurred that corresponded to temperature declines in spring and summer (see Ocean Imaging 2004c, d). However, this imagery did not detect the presence of the wastewater plume in nearshore waters following these events. Similar events have occurred during the past two years and may be the result of inshore movement of water from the California Current (see City of San Diego 2004a).

Like temperature, thermal stratification of the water column followed normal seasonal patterns. Stratification was minimal or absent from January through March with differences between average surface and bottom temperatures being only 1–2.5°C (Figure 2.3, Table 2.1). The absence of a stratified water column is the likely reason that plume-influenced waters were visually detected in near-surface waters during aerial overflights conducted from January through mid-March (Ocean Imaging 2004a, b). The seasonal thermocline began to develop in April at depths between 10–20m, and became shallower and stronger throughout the summer months. From July through September the thermocline was as shallow as 5 m with temperature differences between surface and bottom waters reaching 9.5°C in September. The shallow thermocline persisted into the first part of October, sinking to approximately 15m in November and disappearing in December. During the period of strongest thermoclines (April–September) no plume-influenced waters were visually detected in near-surface waters (Ocean Imaging 2004c, d). By December the thermocline was gone and a persistent, weak, near-surface signature of the plume was detected (Ocean Imaging 2005).

Density is a product of temperature, salinity and pressure (Pickard and Emery 1990). In the San Diego's South Bay area, temperature is the most important component in determining density because of the relatively shallow shelf depth and the relative uniformity of salinity. Therefore, changes in density typically mirror the changes in temperature, as they did in 2004. For example, surface water density was lowest (22.97 δ/θ) in September when surface waters were warmest (22.2°C) (see Table 2.1 and Figures 2.2, 2.3).

Surface water salinity was more variable than in recent years (see City of San Diego 2004a), but nevertheless displayed some seasonal patterns related to increasing air temperatures, rain runoff, and sporadic upwelling events. Surface salinity ranged from 33.08 to 33.50 ppt in 2004 (Table 2.1). During periods of substantial freshwater input from rain storms, near-surface salinity fell below 33 ppt at several shallow stations off the Tijuana River (City of San Diego 2004b, c). These conditions allowed for the development of salinity haloclines near the surface (1–5m) during the late winter and early spring (March–May) and again in late fall and winter (October–December) following rain events.

Increased turbidity of the coastal waters following rainfall events and plankton blooms was readily visible in satellite and aerial imagery. CTD profile data for transmissivity, chlorophyll *a*, and dissolved oxygen generally supported these aerial observations. Nearshore water clarity was significantly impacted by storms in February, October, and December (see Ocean Imaging 2004b, 2005). Transmissivity declined in February and March following storm activity due to increased flow from the Tijuana River (Figures 2.3, 2.4, **2.5A**). The area surrounding the mouth of the river remained contaminated through April (see Chapter 3). During the storms of October–December the outfall region was again subject to frequent terrestrial runoff, primarily from the Tijuana River. The October survey of monthly stations were obtained prior to the record storms of late October, consequently the resulting turbidity observed in aerial imagery is only apparent in transmissivity data from the nearshore stations (Figure 2.2). Recurring rain caused large volumes of turbid runoff along the coast from mid-October through December.

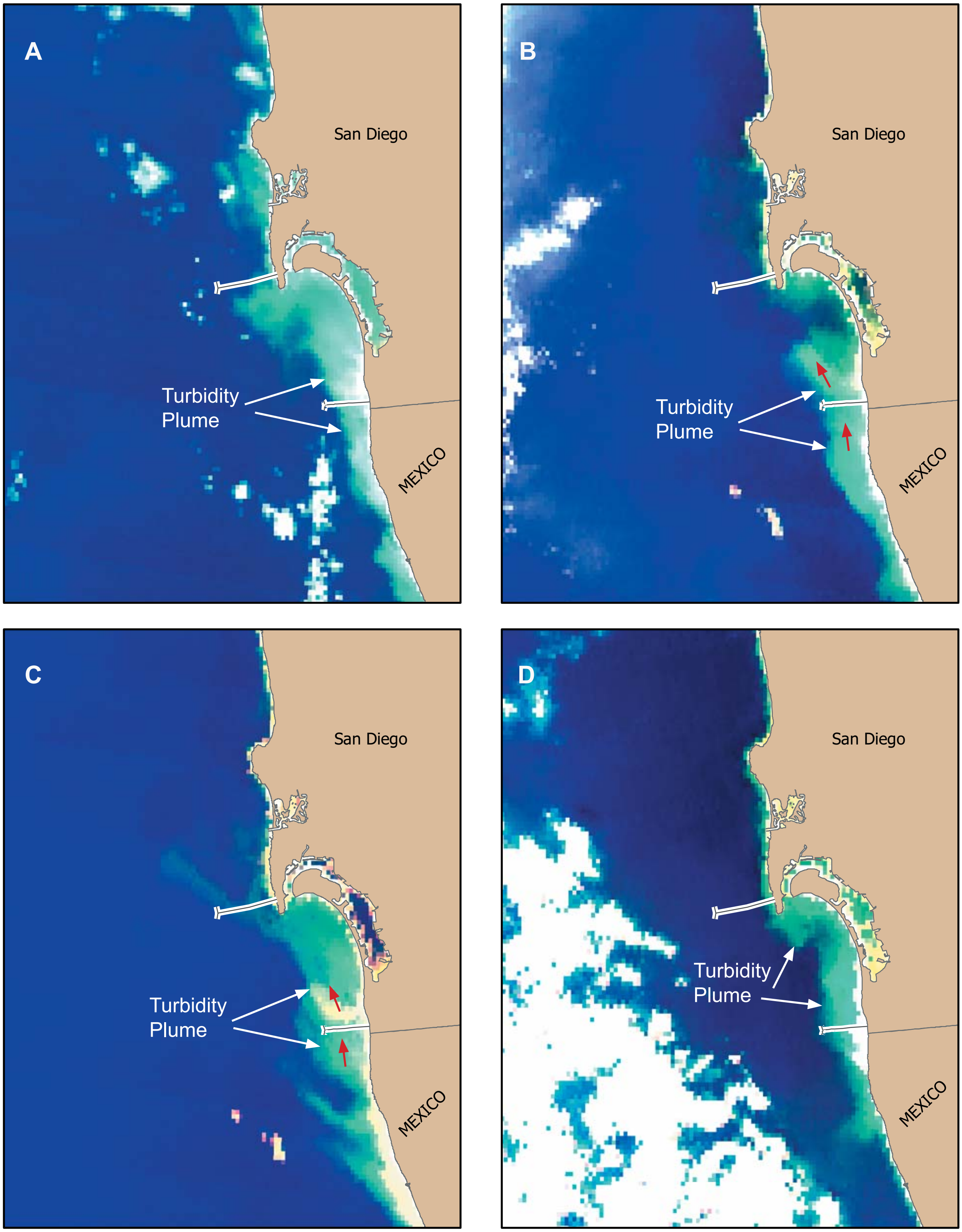

Figure 2.5
MODIS satellite image showing the San Diego water quality monitoring region, captured in 2004 on (A) February 24, (B) October 23, (C) October 30, and (D) December 27. White pixels offshore represent areas obscured by cloud cover. White pixels along the shoreline are the result of “washout” or band saturation due to the histogram stretches used to enhance turbidity features in surface waters.

Northward surface currents carried this very large Tijuana River runoff plume to within 300 m of the outfall wye (Figures 2.5B, C). Even after 20 days without rain DMSC aerial data on December 26 indicated the presence of lingering runoff effects near the outfall area (Figure 2.5D).

Transmissivity was also affected by a regional increase in plankton and wave-caused turbidity over the Tijuana River alluvial fan (Ocean Imaging 2004c, d). During May and June, for example, chlorophyll *a* concentrations increased in the surface waters of the kelp stations and at mid-depths of the offshore sites (Figures 2.3, 2.4). This was accompanied by smaller than expected increases in dissolved oxygen concentrations. Many factors can affect photosynthesis and oxygen production such as the species of plankton present, species succession, population size and position within the water column, nutrient levels, day length, cloud cover, and the time of sampling (Eppley and Holm-Hansen 1986). Water surveys were generally done in the early morning, and maximum levels of oxygen production may not have been achieved upon sampling. Additionally, the lower oxygen value at bottom depths present from May through July is likely due to increased depletion by biological and detrital oxidation (Pickard and Emery 1990). Increased stratification and decaying plankton contribute to this loss of oxygen.

These storm and plankton-driven turbidity patterns in surface waters act as markers of water movement visible in the satellite imagery. From January through September 2004, with few exceptions, aerial imagery of turbidity patterns indicated that water movement was primarily southward (Ocean Imaging 2004a, b, c, d). One exception included a predominantly northward flow that occurred after the first of two significant rain events in April, which caused significant runoff from the Tijuana River to travel as far north as Imperial Beach (Ocean Imaging 2004c). With the transition into fall and the start of record storm activity, surface waters in the outfall region were subject to frequent northward currents. For example, after a heavy storm on October 23 the turbid plume from the Tijuana River reached as far northward and seaward as the SBOO wye (Figure 2.5B). Moreover, during December the outer edge of a very large Tijuana River runoff plume reached to within 300 m of the wye (Ocean Imaging 2005). Despite these occurrences, aerial imagery indicated that the plume generally did not increase in extent after a storm, and riser discharge does not become more visible following early or late rain seasons (Ocean Imaging 2005).

SUMMARY and CONCLUSIONS

Oceanographic conditions during 2004 were generally within expected variability. Above average rainfall was recorded in February, while record rainfall occurred in October and December. The influx of freshwater during these months contributed to shallow haloclines as well as large plumes of turbid water along shore and occasionally near the outfall. Additionally, above average temperatures during the summer contributed to the development of a strong, shallow thermocline/pycnocline that lasted from June through September.

Aerial and satellite imagery detected upwelling events during the summer months that were supported by CTD data in May and June. In addition to upwelled waters, it is likely that cooler, less saline water from the California Current may have been pushed inshore during October leading to a breakdown in stratification between surface and mid-depth waters.

Thermal stratification was strongest from April through mid-October. During summer months (July–September), when water clarity was very high, the wastewater plume was not visible due to the strong thermocline/pycnocline. The thermal stratification that existed throughout most of the year limited detection of the wastewater plume in surface waters. Remote sensing detected the plume at the surface in January and February and in sub-surface shallow waters in March and December. These conditions are supported by patterns of bacterial concentrations discussed in the following chapter.

Reduced water clarity during 2004 was primarily associated with record rainfall and from runoff that resulted in turbid plumes from the Tijuana River and, to a lesser extent, from San Diego Bay. Turbidity associated with the outfall plume did not appear to increase during these events and therefore did not significantly affect regional water clarity. In fact, the observed plume often appeared to move northward and away from the sampling area during periods of greatest storm activity. Chlorophyll concentrations, slight increases in dissolve oxygen levels, and total suspended solids concentrations (see Chapter 3) indicated that plankton blooms contributed to decreased water clarity during May and June. Finally, aerial imagery indicated that runoff from the Tijuana River appeared to be a significant factor in increased turbidity while the plume from the outfall tended to have a less significant effect. In general, the aerial imagery and data for the region's water column properties revealed little evidence of impact from the SBOO.

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Chapter 3. Microbiology

INTRODUCTION

The City of San Diego performs shoreline and water column bacterial monitoring in the region surrounding the South Bay Ocean Outfall (SBOO). Bacteriological densities, together with oceanographic data (see Chapter 2), provide information about the movement and dispersion of wastewater discharged through the outfall. Analyses of these data may also implicate point or non-point sources other than the outfall as contributing to bacterial contamination events in the region. The SBOO monitoring program is designed to assess general water quality and demonstrate level of compliance with the 2001 California Ocean Plan (COP) as required by the NPDES discharge permit. The final results of bacteriological and individual station compliance data are submitted to the International Boundary and Water Commission and San Diego Regional Water Quality Control Board in the form of Monthly Receiving Waters Monitoring Reports. This chapter summarizes and interprets patterns in bacterial concentration data collected during 2004.

MATERIALS and METHODS

Field Sampling

Water samples for bacteriological analyses were collected at fixed shore and offshore sampling sites throughout the year (**Figure 3.1**). Weekly sampling was performed at eleven shore stations to monitor bacteria levels along public beaches. Three shore stations (S0, S2, S3) located south of the US/Mexico border are not subject to COP water contact standards. Eight other shore sites (stations S4–S6, S8–S12) are located within the United States and extend from the border northward to Coronado. These eight stations are subject to COP water contact standards (see **Box 3.1**). In addition, 28 offshore stations were sampled monthly at three discrete depths, usually over a 3-day period. These offshore sites are located in a grid pattern surrounding the outfall, along the 9, 19, 28, 38, and 55-m depth contours. Three of these stations (I25, I26, I39) are considered kelp bed stations subject to the COP water contact standards. These stations were sampled for bacterial analysis an additional four times each month in accordance with NPDES permit requirements. The three kelp stations were selected because of their proximity to suitable substrates for the Imperial Beach kelp bed; however, this kelp bed has been historically transient and inconsistent in terms of size and density (North 1991, North et al. 1993). Thus, these three stations are located in an area where kelp is only occasionally found.

Seawater samples from the 11 shore stations were collected from the surf zone in sterile 250-mL bottles. In addition, visual observations of water

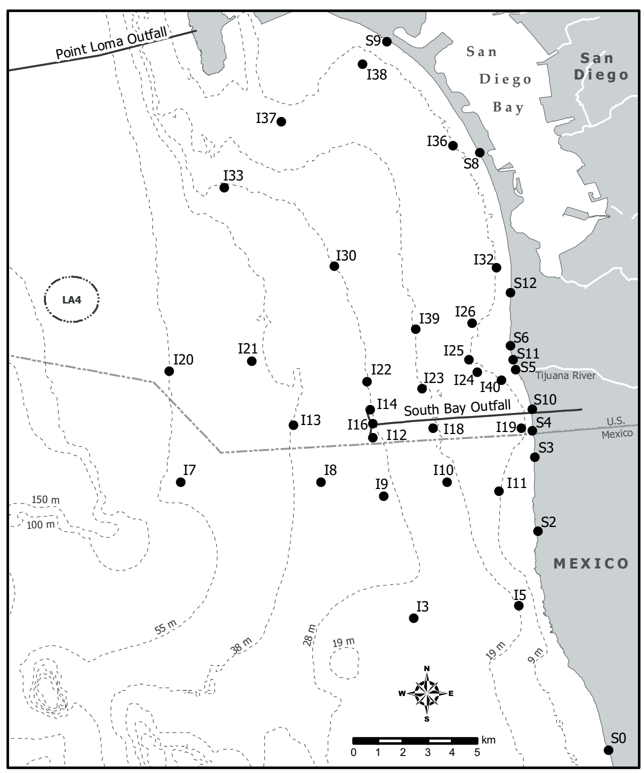

Figure 3.1
Water quality monitoring stations where bacteriological samples were collected, South Bay Ocean Outfall Monitoring Program.

Box 3.1

Bacteriological compliance standards for water contact areas, 2001 California Ocean Plan (CSWRCB 2001). CFU = colony forming units.

(1) *30-day total coliform standard* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 mL.

(2) *10,000 total coliform standard* — no single sample, when verified by a repeat sample collected within 48 hrs, may exceed a concentration of 10,000 CFU per 100 mL.

(3) *60-day fecal coliform standard* — no more than 10% of the samples at a given station in any 60-day period may exceed a concentration of 400 CFU per 100 mL.

(4) *geometric mean* — the geometric mean of the fecal coliform concentration at any given station in any 30-day period may not exceed 200 CFU per 100 mL, based on no fewer than five samples.

color and clarity, surf height, human or animal activity, and weather conditions were recorded at the time of collection. The seawater samples were then transported on ice to the City's Marine Microbiology Laboratory and analyzed to determine concentrations of total coliform, fecal coliform, and enterococcus bacteria.

Offshore samples were analyzed for the same three bacterial parameters, as well as total suspended solids, and oil and grease. These water samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Specific field sampling procedures are outlined in the City's Quality Assurance Plan (City of San Diego in prep). Aliquots for each analysis were drawn into appropriate sample containers. The samples were refrigerated on board ship and then transported to either the City's Marine Microbiology Laboratory for bacterial analyses or to the City's Wastewater Chemistry Laboratory for analysis of oil and grease, and suspended solids. Visual observations of weather and sea state were also recorded at the time of sampling.

Monitoring of the SBOO area and neighboring coastline also included satellite and aerial remote sensing performed by Ocean Imaging Corporation (OI). Satellite imagery included data collected from both Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat Thematic Mapper (TM) instrumentation. The aerial imaging was done using OI's DMSC-MKII digital multispectral sensor (DMSC). Its four channels were configured to a specific wavelength (color) combination, determined by OI's previous research, which maximizes the detection of the SBOO plume's turbidity signature, while also allowing separation between the outfall plume and coastal discharges and turbidity. The depth penetration of the imaging varies between 8 and 15 meters, depending on general water clarity. The spatial resolution of the data is usually 2 meters. Several aerial overflights were performed each month during the rainy season and a lesser number during the dry season.

Laboratory Analyses and Data Treatment

All bacterial analyses were performed within eight hours of sample collection and conformed to the membrane filtration techniques outlined in the City's Quality Assurance Plan (City of San Diego in prep). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services (CS-DHS), Water Laboratory Approval Group with respect to sampling and analytical procedures (Bordner, et al. 1978; Greenberg, et al. 1992).

Colony counting, calculation of results, data verification and reporting all follow guidelines established by the EPA (see Bordner, et al. 1978). According to these guidelines, plates with bacterial counts above or below permissible counting limits were given greater than (>), less than (<), or estimated (e) qualifiers. However, these qualifiers were dropped and the counts were treated as discrete values during the calculation of compliance with COP standards and various statistical analyses.

Spatial and temporal patterns in bacteriological contamination were determined from mean densities of total coliform, fecal coliform, and enterococcus bacteria. These data were calculated for each station by month, station, and depth and evaluated relative to monthly rainfall and climatological data collected at Lindbergh Field, San Diego, CA, oceanographic conditions (see Chapter 2), as well as other events (e.g., storm water flows, nearshore and surface water circulation patterns) identified through satellite and aerial sensing data collected by OI. Shore and kelp bed station compliance with COP bacteriological standards were summarized according to the number of days that each station was out of compliance with the 30-day total coliform, 10,000 total coliform, 60-day fecal coliform, and geometric mean standards (see Box 3.1). Bacteriological data for offshore stations data are not subject to COP standards; however, these data were used to examine spatio-temporal patterns in the dispersion of waste field. Bacteriological benchmarks for receiving waters discussed in this report are ≥ 1000 CFU/100 mL for total coliform values, ≥ 400 CFU/100 mL for fecal coliforms, and ≥ 104 CFU/100 mL for enterococcus bacteria. These benchmarks are used as reference points to distinguish elevated bacteriological values. Generally, contaminated waters can be identified when total coliform concentrations are ≥ 1000 CFU/mL and the fecal:total (F:T) ratio is ≥ 0.1 (see CS-DHS 2000). Offshore station water quality samples that met these criteria were used as indicators of the waste field.

Quality assurance tests were performed routinely on water samples to ensure that sampling variability did not exceed acceptable limits. Duplicate and split field samples were collected according to method requirements and processed by laboratory personnel to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in the Laboratory's Quality Assurance Report (City of San Diego 2005).

RESULTS and DISCUSSION

Temporal Variability

The annual mean concentrations of total coliform, and fecal coliform, and enterococcus bacteria along the shoreline in 2004 were generally higher than in 2003, and in many cases exceeded levels not seen since the 1998 El Niño (**Figure 3.2**). These higher values could be attributed to the increased rainfall in 2004 (9.2 inches in 2003 compared to 13.3 inches in 2004). This is particularly true for record rainfall that occurred in October and December of 2004 (>4 inches/month) (**Table 3.1**). The highest densities of indicator bacteria occurred from February to April and October to December during periods of heavy rainfall (3.6 and 9.3 inches, respectively). In contrast, bacterial contamination in the region was sporadic during the subsequent warm and dry conditions of May through September. There was only one instance when total coliform concentrations exceeded 10,000 CFU/100 mL during these months (6 July at station SO), compared to 92 instances during the remainder of the year (i.e., January–April, October–December). Differences between the wet and dry seasons were particularly evident for bacterial concentrations at shore stations near the Tijuana River (i.e., S4, S5, S6, S10, S11) where contaminants from upstream sources (e.g., sod farms) and the estuary (e.g., decaying plant

Table 3.1
Shore station bacteriological densities and rainfall data for the SBOO region during 2004. Mean total coliform, fecal coliform, and enterococcus (Entero) bacteria densities are expressed as CFU/100 mL. Mean rainfall is expressed in inches as measured at Lindbergh Field, San Diego, CA. Sample size (n) for each station is given in parentheses.

Month / Rainfall		S09 (54)	S08 (53)	S12 (56)	S06 (62)	S11 (63)	S05 (65)	S10 (57)	S04 (57)	S03 (52)	S02 (52)	S0 (52)
Jan	Total	3	205	1973	8	133	6767	1206	1656	342	46	8010
0.34	Fecal	2	3	22	3	4	244	27	18	12	5	437
	Entero	4	2	57	7	8	18	13	25	31	16	141
Feb	Total	2228	1613	5608	6408	6404	6817	2	4	2098	1204	4443
2.81	Fecal	99	146	276	601	682	2689	2	2	139	87	1569
	Entero	110	152	648	1844	2762	2583	2	2	510	212	1717
Mar	Total	8	4	2691	2968	3082	6643	6402	5603	3522	1620	280
0.22	Fecal	2	2	1036	336	1389	4039	2961	1249	218	43	7
	Entero	2	9	35	18	25	4053	112	47	164	32	16
Apr	Total	16	7	267	6177	6809	6160	6429	6465	4016	20	3259
0.60	Fecal	2	2	16	1134	715	1176	5003	3842	402	3	92
	Entero	2	2	2	15	14	29	298	249	23	2	24
May	Total	7	22	21	7	19	1626	9	18	10	10	1201
0.01	Fecal	2	7	3	4	6	1356	3	4	4	3	45
	Entero	12	123	3	5	6	1667	7	8	3	8	7
Jun	Total	88	47	85	14	8	85	27	28	24	17	8
0.00	Fecal	6	4	9	2	2	34	10	3	4	3	3
	Entero	2	134	3	2	2	24	2	4	3	8	3
Jul	Total	140	101	65	61	21	36	96	85	12	11	4171
0.00	Fecal	25	4	6	2	6	8	17	8	5	3	756
	Entero	62	5	3	2	6	15	17	22	3	4	146
Aug	Total	1699	49	20	46	17	6	104	89	183	28	248
0.00	Fecal	2	2	8	2	3	4	12	17	19	3	19
	Entero	2	2	7	3	5	2	6	6	7	3	6
Sep	Total	25	3	58	61	63	106	63	22	120	33	239
0.00	Fecal	5	2	5	4	14	6	4	8	12	3	27
	Entero	3	3	5	5	6	4	3	8	24	9	47
Oct	Total	6405	6412	5429	6472	7161	10673	5335	5339	8006	4331	289
4.98	Fecal	3367	4802	2588	4021	4425	6701	4001	4005	3701	292	45
	Entero	2414	2486	2512	3669	3669	6050	208	181	3102	117	39
Nov	Total	24	6	2714	7574	15667	14467	6237	5502	2473	924	408
0.33	Fecal	21	6	263	479	4796	4118	497	304	142	60	35
	Entero	4	4	48	77	350	1637	76	102	43	36	96
Dec	Total	1093	779	6489	7966	6456	8330	6505	5199	5405	2350	2533
4.01	Fecal	69	18	2610	3087	3004	4053	225	293	3055	69	47
	Entero	56	29	2903	2852	3129	2959	79	138	3069	81	215
Annual	**Total**	**1080**	**821**	**2275**	**3685**	**4863**	**6099**	**3130**	**2851**	**2135**	**865**	**1948**
Means	**Fecal**	**331**	**468**	**628**	**877**	**1556**	**2375**	**1086**	**794**	**601**	**46**	**238**
	Entero	**245**	**272**	**555**	**735**	**828**	**1768**	**73**	**72**	**541**	**42**	**191**

material) are released during periods of increased river flow (**Figure 3.3**). The increased frequency of northward flow of nearshore waters from October to December (see Chapter 2) resulted in stations north of the Tijuana River having relatively high average values later in the year (see City of San Diego 2004).

Bacteriological data from monthly water quality sampling also showed distinct seasonal trends related to rainfall and subsequent storm discharge in 2004 (**Figure 3.4A**). For example, of the 80 instances where bacterial samples were equal to or exceeded the benchmark value of 1000 CFU/100mL, 75% (60 samples) occurred during March, April, November, and December when storm run-off was greatest (see **Appendices A.1, A.2**).

Spatial Variability

Water samples with bacterial densities indicative of the wastewater plume were detected most frequently along the 28-m contour near the discharge site (Figure 3.4B). Seventeen samples with total coliforms ≥ 1000 CFU/100 mL and fecal:total (F:T) ratios ≥ 0.1 were collected at three outfall stations (I12, I14, I16), while three others were collected north of the SBOO at stations I22 and I30, and two more were collected southward at stations I3 and I9. Nine more such samples were collected at several nearshore stations (i.e., I18, I25, I32, I39); however, all but one instance occurred in March, April, or December and were likely related to discharge from the Tijuana River and Los Buenos Creek (see Ocean Imaging 2004a). For example, the April samples were impacted by the first storm of April (2 April) preceded the monthly survey (April 5–7). The storm occurred during a period of northward current flow that carried discharge from Los Buenos Creek and the Tijuana River up coast towards Imperial Beach, affecting water quality at several nearshore stations (see **Figure 3.5A** and Appendices A.1, A.2).

Bacteriological evidence of the wastewater plume reaching surface waters was limited to just a few

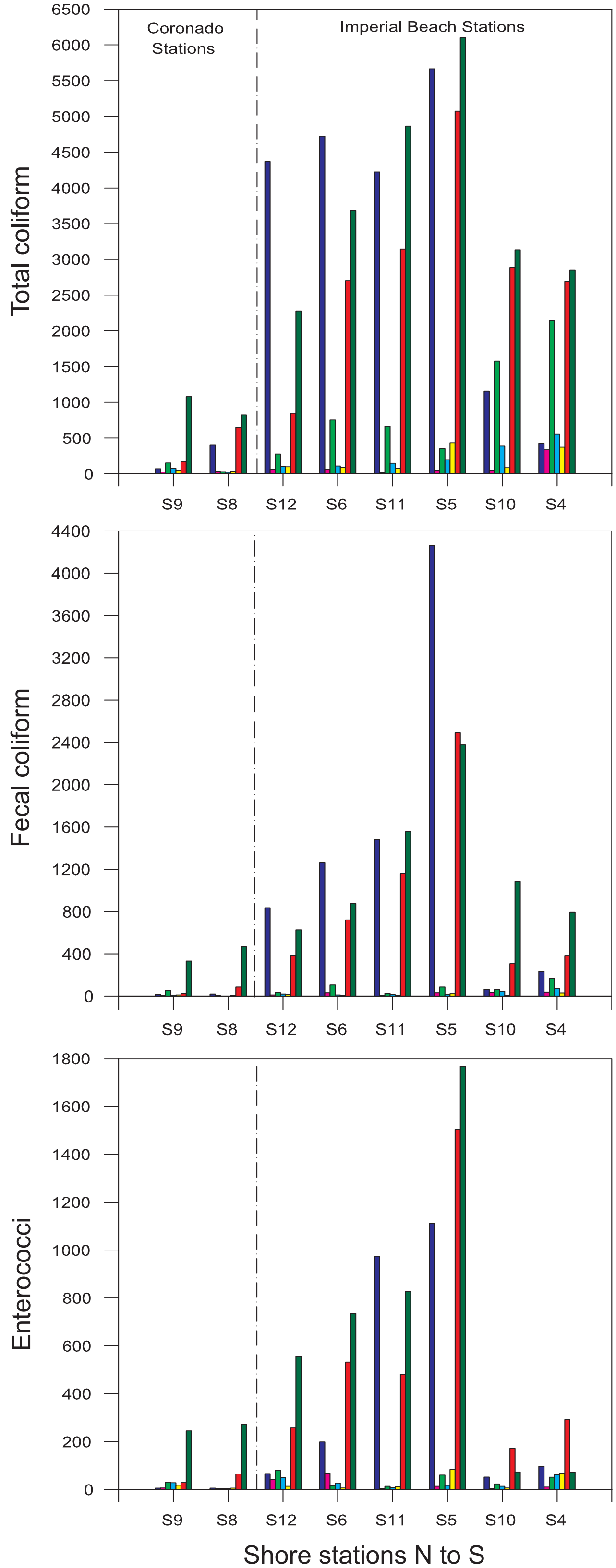

Figure 3.2
Average annual total coliform, fecal coliform, and enterococcus bacteria densities (CFU/100 mL) for each US-based SBOO shore station, 1998–2004.

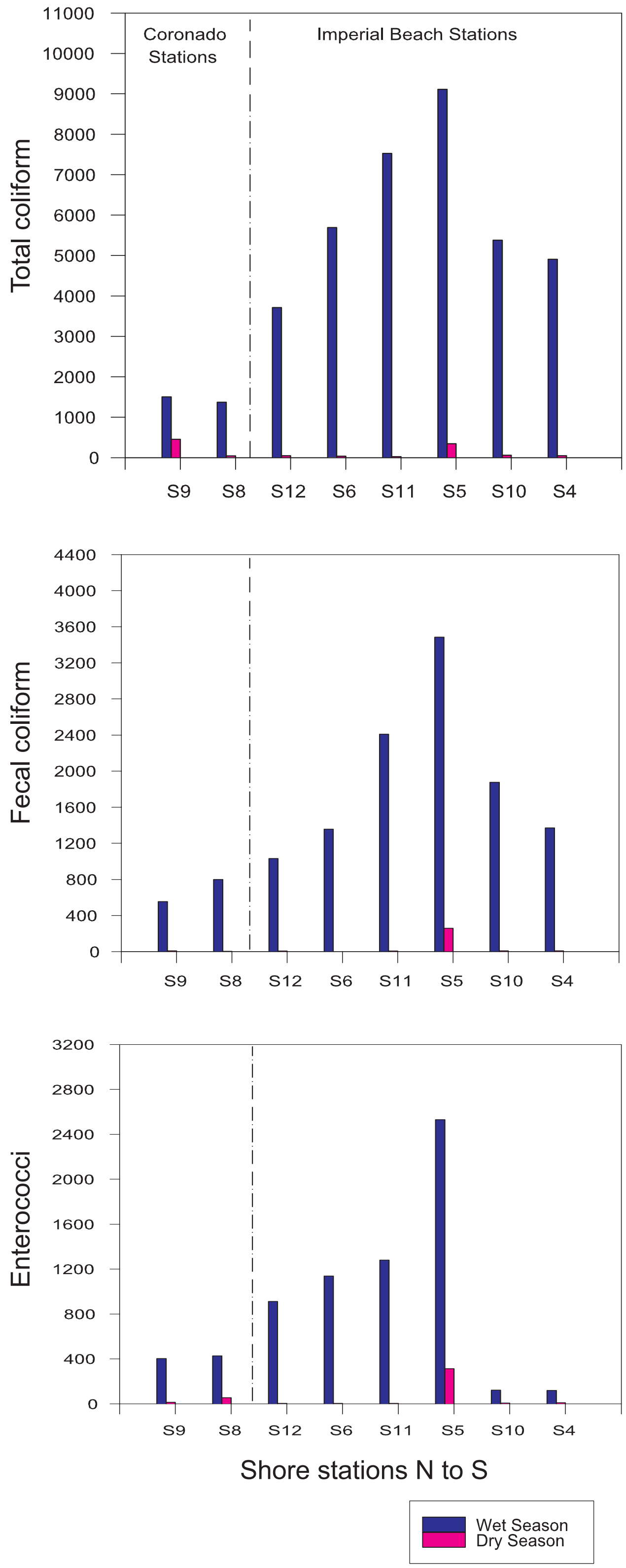

Figure 3.3

Mean total coliform, fecal coliform, and enterococcus bacteria densities (CFU/100 mL) for US-based SBOO shore stations during wet months (January–April, October–December) versus dry months (May–September), 2004.

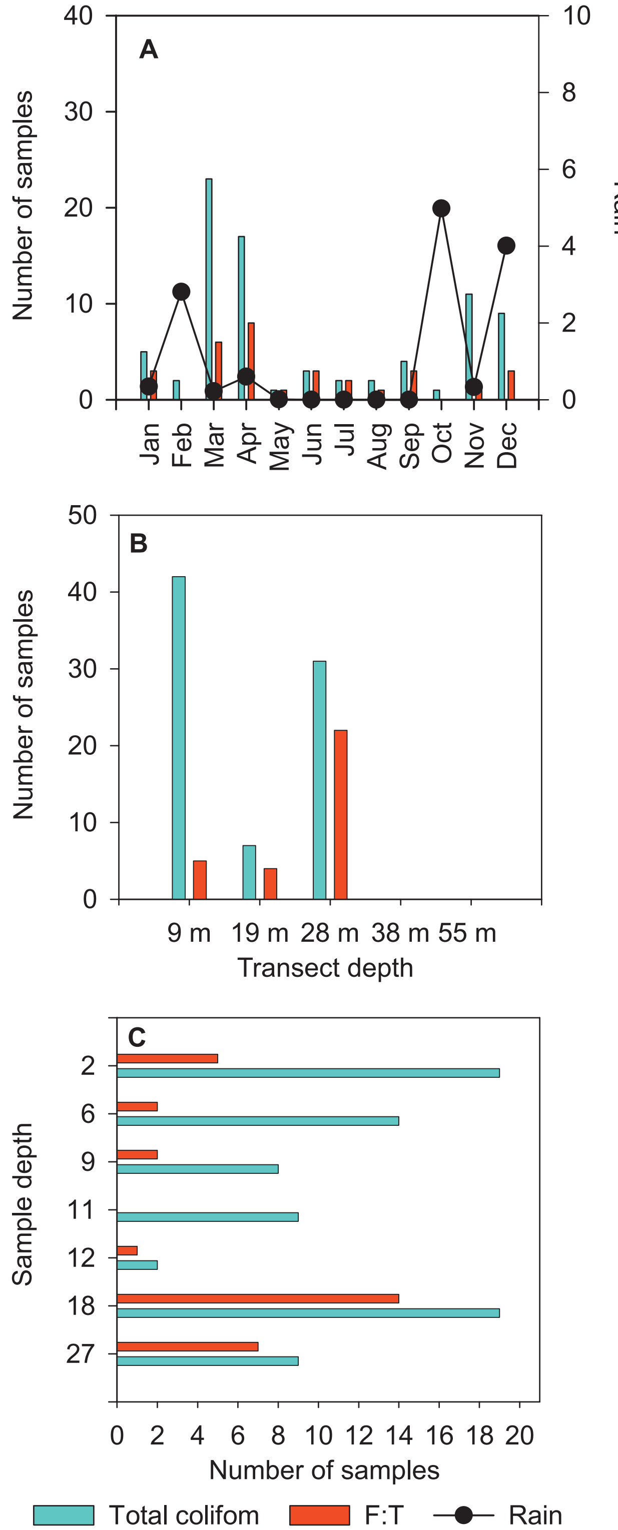

Figure 3.4

Number of SBOO monthly water quality samples collected (A) per month, (B) by transect, (C) by depth in 2004 where total coliform densities were ≥ 1000 CFU/100 mL, relative to the number of samples with total coliform densities ≥ 1000 CFU/100 mL *and* fecal to total coliform ratio (F:T) ≥ 0.1 (see text). Mean rainfall is expressed in inches as measured at Lindbergh Field, San Diego, CA.

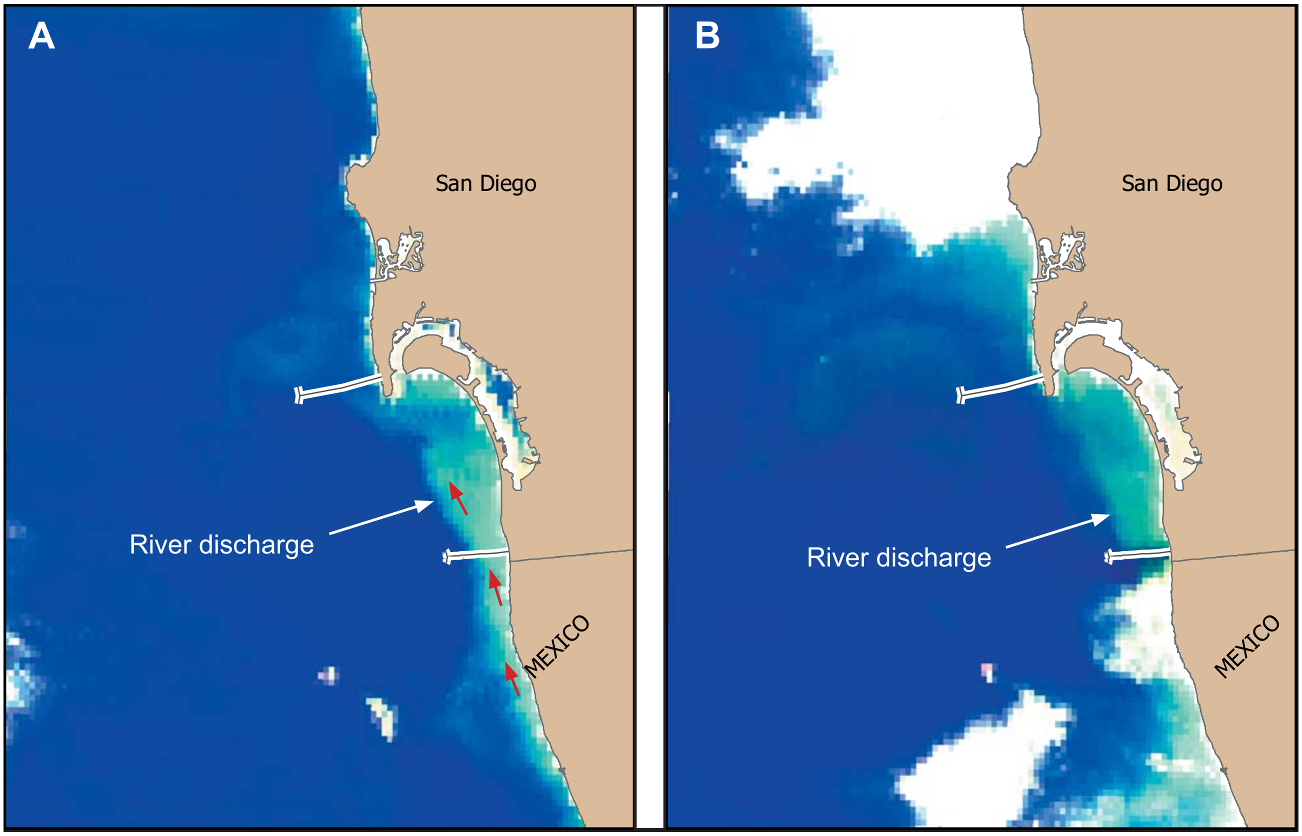

Figure 3.5
MODIS satellite image showing the San Diego water quality monitoring region, captured on (A) April 5, 2004 and (B) March 6, 2004. White pixels represent areas obscured by cloud cover.

occurrences. Of the 31 water samples collected in 2004 with total coliform densities ≥ 1000 CFU/100 mL and F:T ratios ≥ 0.1, only five occurred in surface water samples (2 m) (Figure 3.4C). All five of these samples were collected in January (n=1), March (n=3), or December (n=1) (Appendix A.1). In contrast, from April through November, samples indicative of contaminated waters were restricted to waters 6 m or deeper. For example, densities of all three indicator bacteria along the 27-m contour were highest in the surface waters in January, March, and December and relatively low the other months (**Figure 3.6**). Bottom water bacteriological densities were generally highest in April, but variable throughout the year. Mixing of the water column most likely allowed plume material to surface near the outfall early in the winter months, while a stratified water column that lasted from April through November restricted the plume to mid- and deep-water depths (see Chapter 2).

High bacterial densities along the shoreline and in shallow, nearshore waters were related to sources other than the SBOO. Transport of Tijuana River water affected bacterial counts along the shoreline and various nearshore stations (see Ocean Imaging 2004a, b, 2005). For example, river discharge in February–April and late October–December was likely responsible for elevated total coliform concentrations in shore stations samples surrounding the river mouth (particularly at stations S5, S6, and S11) and nearshore stations along the 9-m contour (see Chapter 2, Figure 2.5). The low frequency of samples with total coliforms ≥ 1000 CFU/100 mL and F:T ratios ≥ 0.1 along the 9-m contour suggest that most of these samples were probably not representative of wastewater discharge, but more likely related to stormwater runoff (see Appendix A.2). For example, samples with elevated bacterial counts were collected from 17 nearshore stations on March 2 and 3, but

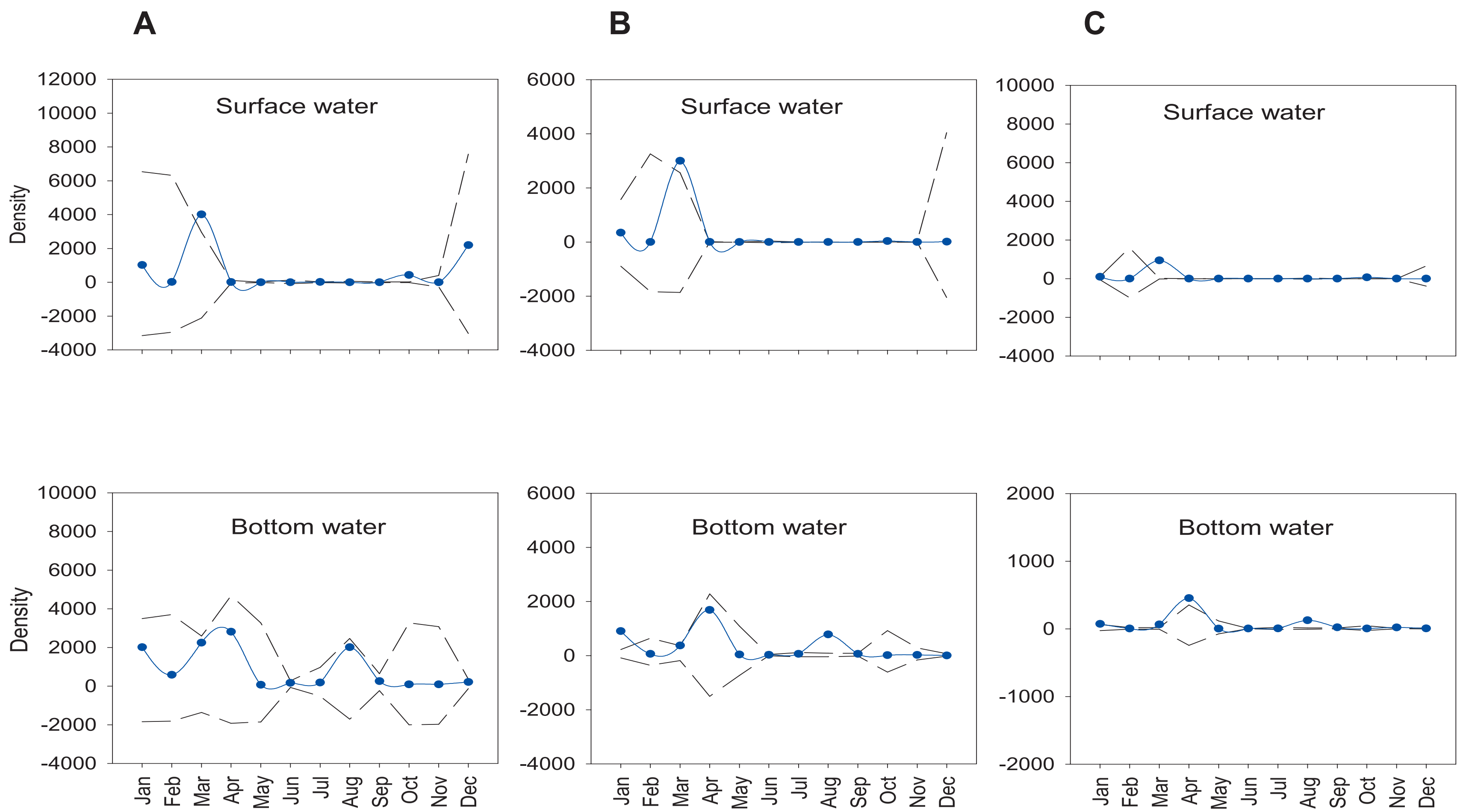

Figure 3.6
Mean concentrations (CFU/100 mL) and standard deviations at SBOO stations along the 27-m contour for surface waters (2 m) and bottom waters (27 m) during 2004: (A) Total coliform, (B) fecal coliform, and (C) enterococcus bacteria.

Table 3.2

Summary of compliance with 2001 California Ocean Plan water contact standards for SBOO shore and kelp bed stations during 2004. Values reflect the number of days that each station exceeded the 30-day and 10,000 total coliform standards (see Box 3.1). Shore stations are listed north to south in order from left to right.

30-day Total Coliform Standard					**Shore stations**					**Kelp stations**		
Month	**# days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I25**	**I26**	**I39**
January	31	0	0	3	20	0	31	31	20	0	0	0
February	29	0	4	23	5	5	29	4	25	3	3	0
March	31	0	16	25	31	31	31	23	23	19	19	30
April	30	0	0	0	17	29	30	30	30	17	0	0
May	31	0	0	0	19	19	31	5	5	0	0	0
June	30	0	0	0	0	0	15	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	26	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	12	12	12	12	12	12	6	6	10	10	10
November	30	17	17	30	30	30	30	30	30	27	30	27
December	31	19	2	23	26	31	31	31	31	4	23	1
Percent Compliance		**80%**	**86%**	**68%**	**56%**	**57%**	**34%**	**56%**	**54%**	**78%**	**77%**	**81%**
10,000 Total Coliform Standard												
January	31	0	0	0	0	0	1	0	0	0	0	0
February	29	0	0	1	1	1	1	0	0	0	0	0
March	31	0	0	0	0	0	1	1	1	0	0	0
April	30	0	0	0	0	0	0	1	1	0	0	0
May	31	0	0	0	0	0	0	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	1	1	1	1	1	2	0	0	2	1	1
November	30	0	0	0	1	4	3	0	0	0	1	0
December	31	0	0	2	2	1	1	0	0	0	1	0
Total		**1**	**1**	**4**	**5**	**7**	**9**	**2**	**2**	**2**	**3**	**1**

only two had total coliforms ≥ 1000 CFU/100 mL and F:T ratios ≥ 0.1. Aerial imagery collected on March 6, four days after a rain event, showed river discharge continuing to impact nearshore water quality (Figure 3.5B). Overall, there was no direct evidence that the wastewater plume reached the shoreline in 2004.

Compliance with California Ocean Plan Standards – Shore and Kelp Bed Stations

Compliance with California Ocean Plan (COP) bacterial standards for U.S. shore and kelp bed stations is summarized in **Tables 3.2** and **3.3**. Increased rainfall in 2004 affected overall compliance with COP standards and caused the lowest compliance rates since 1999 when discharge began and compliance monitoring became required (see City of San Diego 1999–2004). For example, the range for percent compliance with the 30-day total coliform standard at the shore stations in 2003 was 52–95% but dropped to 34–86% in 2004. The frequency of non-compliance for standards based on running means (i.e., the 30-day total, 60-day fecal, and geometric mean standards) was greatest in November, following the wettest October of record. On the other hand, the most frequent exceedences for the 10,000 coliform standard, based on a repeat sample within 48-hours, occurred in October as a result of storm water runoff.

Table 3.3

Summary of compliance with 2001 California Ocean Plan water contact standards for SBOO shore and kelp bed stations during 2004. Values reflect the number of days that each station exceeded the 60-day and geometric mean standards for fecal coliforms (see Box 3.1). Shore stations are listed north to south in order from left to right.

60-day Fecal Coliform Standard		Shore stations								Kelp stations		
Month	**# days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I25**	**I26**	**I39**
January	31	0	0	0	0	12	16	0	0	0	0	0
February	29	3	6	6	6	17	29	0	0	0	0	0
March	31	13	31	31	31	31	31	23	23	9	0	0
April	30	9	23	26	30	30	30	30	30	25	0	0
May	31	0	0	0	31	0	19	31	31	0	0	0
June	30	0	0	0	9	0	30	5	5	0	0	0
July	31	0	0	0	0	0	23	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	13	13	13	13	13	13	6	6	10	10	10
November	30	30	30	30	30	30	30	30	30	30	30	30
December	31	18	18	31	31	31	31	31	31	20	31	20
Percent Compliance		**77%**	**67%**	**63%**	**51%**	**55%**	**31%**	**57%**	**57%**	**74%**	**81%**	**84%**
Geometric Mean Standard												
January	31	0	0	0	0	0	0	0	0	0	0	0
February	29	0	0	0	0	0	0	0	0	0	0	0
March	31	0	0	0	5	5	30	0	0	0	0	0
April	30	0	0	0	0	0	7	1	0	0	0	0
May	31	0	0	0	0	0	3	0	0	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	0	0	0	0	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	0	0	0	0	0	0	0	0
October	31	0	0	0	0	0	5	0	0	0	0	0
November	30	5	0	7	26	28	30	7	7	19	20	0
December	31	0	0	0	0	22	31	0	0	0	0	0
Percent Compliance		**99%**	**100%**	**98%**	**92%**	**85%**	**71%**	**98%**	**98%**	**95%**	**95%**	**100%**

As in previous years, stations located near the Tijuana River mouth exceeded the water quality standards more frequently than those farther northward. Only the three northernmost shore stations (i.e., S8, S9, S12) were compliant with COP standards over 60% of the time. In contrast, compliance at the more southern shore stations (i.e., S4, S5, S6, S10, S11) was less than 60% for the 30-day total and 60-day fecal coliform standards. The proximity of these five stations to the Tijuana River may explain the frequency with which they were out of compliance. An increased frequency of northward flow of surface waters from October–December 2004 (see Chapter 2) was probably responsible for the decreased compliance at stations north of the Tijuana River (i.e., S5, S6, S11) relative to previous years (see City of San Diego 2004).

All three kelp stations showed a similar pattern of increased incidence of non-compliance during periods of heavy rainfall (Tables 3.2, 3.3). While the three stations were compliant with the COP standards over 74% of the time, the highest incidences of non-compliance occurred in February and October–December. As with the shore stations, increased northward flow of surface waters from October through December affected compliance at stations northward of the Tijuana River (i.e., I26 and I39) in 2004 relative to previous years. For example, in prior years, the

Table 3.4
Monthly mean values for total suspended solids (SuSo) and 2 m oil and grease (O&G) samples for each SBOO offshore station during 2004. Ranges are given in parentheses.

	O&G	SuSo
January	0.58 (0.2–3.2)	3.6 (0.2–9.9)
February	0.20 (0.2)	5.3 (0.2–45.8)
March	0.20 (0.2)	5.9 (0.2–30.5)
April	0.20 (0.2)	4.8 (0.2–12.7)
May	0.20 (0.2)	5.4 (0.2–15.2)
June	0.20 (0.2)	6.4 (0.2–48.8)
July	0.20 (0.2)	3.8 (0.2–11.9)
August	0.20 (0.2)	5.0 (0.2–21.5)
September	0.20 (0.2)	5.0 (0.2–12.9)
October	0.20 (0.2)	6.1 (0.2–19.5)
November	0.34 (0.2–4.21)	6.7 (1.9–29.2)
December	0.25 (0.2–1.72)	4.2 (0.2–68.2)

station farthest from shore (I39) was compliant with COP standards over 90% of the time, but in 2004 compliance with the 30-day total and 60-day fecal coliform standards fell to 81 and 84%, respectively. In general, it appears that shore and kelp station compliance with COP standards in 2004 was affected most by shore-based discharges that increased during periods of rainfall.

Bacterial Patterns Compared to Other Wastewater Indicators

Monthly mean concentrations of oil and grease were generally low (<0.6 mg/L) (**Table 3.4**). Individual values ranged from 0.2–4.2 mg/L, with the concentrations of approximately 2.0 mg/L or higher occurring in January (i.e., stations I11, I12, I14, I18) and November (I13). However, corresponding bacterial concentrations in the 2 m surface samples were very low (i.e., ≤ 18 CFU/100 mL) at all but station I12. The I12 sample had total coliforms ≥1000 CFU/100 mL and a F:T ratio of 0.34, with visual observations from that day indicating the presence of the wastewater plume at the surface. This observation is not unexpected since it occurred when the water column was well-mixed (see Chapter 2).

Monthly mean concentrations of total suspended solids (TSS) ranged from 3.6 to 6.7 mg/L (Table 3.4). Individual values varied considerably, ranging between 0.2–68.2 mg/L, and did not correspond to bacterial concentrations. For example, there were 94 TSS samples with concentrations ≥ 10.0 mg/L, but only 14 (15%) correspond to samples where total coliform values were ≥ 1000 CFU/100 mL, and only five of these had F:T ratios ≥ 0.1. Instead, elevated TSS values corresponded primarily to storm water discharges and plankton concentrations (see Chapter 2). The second highest TSS concentration was recorded in June at nearshore station I39 (18 m sample). All corresponding bacteriological indicators were below 10 CFU/100 mL, while chlorophyll *a* and dissolved oxygen values were relatively high indicating the presence of plankton. Taken together, these results suggest a limited utility for high suspended solids or oil and grease concentrations as indicators of the waste field.

SUMMARY and CONCLUSIONS

Bacteriological data for the South Bay region indicate that the wastewater plume from the South Bay Ocean Outfall (SBOO) was confined below a stratified water column from April through November and dispersed rapidly whenever transported laterally. Elevated bacterial counts were evident near the surface only during January, March, and December when the water column was well-mixed. Data from remote sensing suggests a predominantly southward flow of the surface waters to 15 m from January–September and a northward flow from October–December. Concentrations of bacterial indicators from monthly sampling events detected the wastewater plume at depths of 18 m and below and predominantly near the discharge site for most of the year.

Water quality conditions for the South Bay region were strongly influenced by record rainfall in 2004. For the most part, values exceeding compliance levels along the shore and at kelp bed stations appear to have been caused by contamination from non-outfall sources released during and after storm events. Patterns of bacterial concentration and visible satellite imagery data indicate that contributions from the Tijuana River, Los Buenos Creek, and non-point source stormwater runoff are all more likely than the SBOO to have a critical impact on the water quality at shore and nearshore stations.
Together, these data suggest that even though elevated bacterial densities were detected at the shore and nearshore stations at various times during the year, there was no evidence that this resulted from shoreward transport of the SBOO waste field. Overall, even with the presence of major storm activity in February, October, and December, the bacterial data demonstrated minimal, if any, impact to nearshore water quality from the SBOO discharge during 2004.

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Chapter 4. Sediment Characteristics

INTRODUCTION

Sediment conditions can influence the distribution of benthic invertebrates by affecting the ability of various species to burrow, build tubes or feed (Gray 1981, Snelgrove and Butman 1994). In addition, many demersal fishes are associated with specific sediment types that reflect the habitats of their preferred prey (Cross and Allen 1993). Both natural and anthropogenic factors affect the distribution, stability, and composition of sediments. Ocean wastewater outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of ocean sediments through discharge and deposition of a wide variety of organic and inorganic compounds. Some of the most commonly detected compounds discharged via outfalls are trace metals, pesticides, and various organic compounds (e.g., organic carbon, nitrogen, and sulfide compounds) (see Anderson et al. 1993). Moreover, the presence of the large concrete pipe or associated structures can alter the hydrodynamic regime in the immediate area.

Natural factors that affect the distribution and stability of sediments on the continental shelf include bottom currents, wave exposure, proximity to river mouths, sandy beaches, submarine basins, canyons and hills, and the presence and abundance of calcareous organisms (Emery 1960). The analysis of various sediment parameters (e.g., particle size, sorting coefficient, and percentages of sand, silt and clay) can provide useful information relevant to the amount of wave action, current velocity, and sediment stability in an area.

The chemical composition of sediments can also be affected by the geological history of an area. For example, sediment erosion from cliffs and shores, and the flushing of sediment particles and terrestrial debris from bays, rivers, and streams, contribute to the composition of metals and organic content within the area. Additionally, nearshore primary productivity by marine plankton contributes to the organic input in marine sediments (Mann 1982, Parsons et al. 1990). Concentrations of these materials within ocean sediments generally increase with increasing amounts of fine sediment particles chiefly as a result of adsorption (Emery 1960).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2004 in the vicinity of the South Bay Ocean Outfall (SBOO). The major goals are to: (1) assess possible impact of wastewater discharge on the benthic environment by analyzing the spatial and temporal variability of the various sediment parameters, and (2) determine the presence or absence of sedimentary and chemical footprints near the discharge site.

MATERIALS and METHODS

Field Sampling

Sediment samples were collected during January and July of 2004 at 27 stations surrounding the SBOO (**Figure 4.1**). These stations are located along the 19, 28, 38, and 55-m depth contours and form a grid surrounding the terminus of the outfall. A chain-rigged 0.1 m^2 Van Veen grab was used to collect each sample. Sub-samples for various analyses were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

Laboratory Analyses

All sediment chemistry and grain size analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory. Particle size analysis was performed using a Horiba LA-920

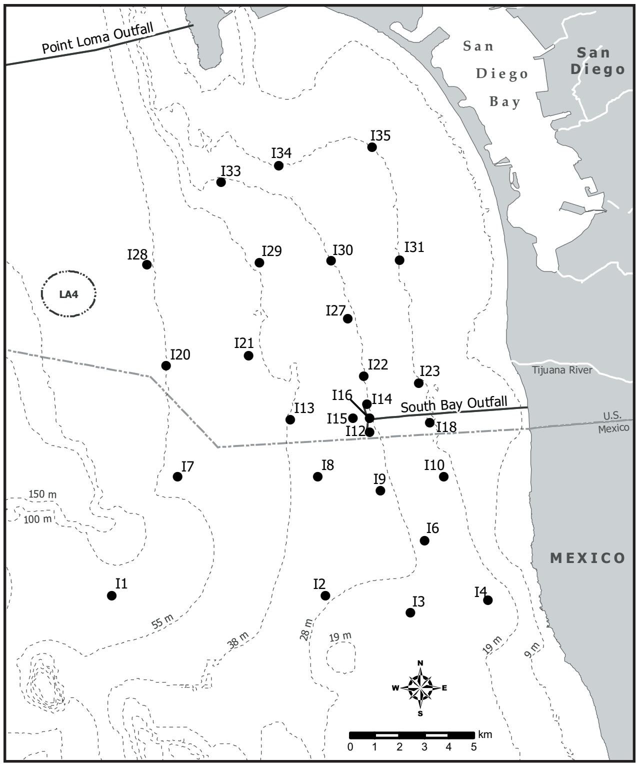

Figure 4.1
Sediment chemistry station locations, South Bay Ocean Outfall Monitoring Program.

laser scattering particle analyzer, which measures particles ranging in size from -1 to 11 phi (i.e., 0.00049–2.0 mm; sand, silt, and clay fractions). Coarser sediments (e.g., very coarse sand, gravel, and shell hash) were removed prior to analysis by screening the samples through a 2.0 mm mesh sieve. These data were expressed as the percent "Coarse" of the total sample sieved.

A more sensitive ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry) technique for analysis of metals was introduced mid-year of 2003. An IRIS axial ICP-AES system replaced the Atomscan radial ICP-AES. The superior abilities of the IRIS axial ICP-AES lowered the method detection limits by approximately an order of magnitude. Consequently, low concentrations of metals that would not have been detected in previous surveys were detected during the July 2003 survey and the 2004 surveys.

Data Analyses

The data output from the Horiba particle size analyzer was categorized as follows: sand was defined as particles ranging in size from >-1 to 4.0 phi, silt as particles from >4.0 to 8.0 phi, and clay as particles >8.0 phi (see Wentworth Scale, **Table 4.1**). These data were standardized and incorporated with a sieved coarse fraction containing particles >2.0 mm in diameter to obtain a distribution of coarse, sand, silt, and clay totaling 100%. The coarse fraction was included with the phi -1 fraction in the calculation of various particle size parameters, which were determined using a normal probability scale (see Folk 1968). The parameters included mean and median phi size, standard deviation of phi size (sorting coefficient), skewness, kurtosis, and percent sediment type (i.e., coarse, sand, silt, clay).

Chemical parameters analyzed were total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl compounds (PCBs) (see **Appendix B.1**). Generally, values below method detections limits are treated as "not detected" (i.e., Null). However, some parameters (e.g., PAH compounds) were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry) at levels below the MDL. These values were included in the data as estimated values. Null ("not detected") values were treated as zero values when performing statistical calculations or estimating overall means for the region.

Concentrations of the sediment constituents that were detected in 2004 were compared to average results from previous years, including pre-discharge (1995–1998) and post-discharge (1999–2003) periods. In addition, values for metals, TOC, TN, and pesticides (i.e., DDE) were compared to median values for the Southern California Bight that were based on the cumulative distribution function (CDF) for each parameter

Table 4.1

A subset of the Wentworth scale representative of the sediments encountered in the SBOO region. Particle size is presented in phi, microns, and millimeters along with the conversion algorithms. The sorting coefficients (standard deviation in phi units) are based on categories described by Folk (1968).

Wentworth Scale				Sorting Coefficient	
Phi Size	Microns	Millimeters	Description	Standard Deviation	Sorting
-2	4000.0	4.000	Pebble	Under 0.35 phi	very well sorted
-1	2000.0	2.000	Granule	0.35–0.50 phi	well sorted
0	1000.0	1.000	Very coarse sand	0.51–0.70 phi	moderately well sorted
1	500.0	0.500	Coarse sand	0.71–1.00 phi	moderately sorted
2	250.0	0.250	Medium sand	1.01–2.00 phi	poorly sorted
3	125.0	0.125	Fine sand	2.01–4.00 phi	very poorly sorted
4	62.5	0.063	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31.0	0.031	Coarse silt		

Conversions for Diameter in Phi to Millimeters: D (mm) = 2^{-phi}
Conversions for Diameter in Millimeters to Phi: D (phi) = -3.3219 log 10 D (mm)

(see Schiff and Gossett 1998). These CDFs were established for the Southern California Bight using data from a region-wide survey in 1994, and are presented as the 50% CDF in the tables included herein. Levels of contamination were further evaluated by comparing the results of this study to the Effects Range Low (ERL) sediment quality guideline of Long et al. (1995). The ERL was originally calculated to provide a means for interpreting monitoring data by the National Status and Trends Program of the National Oceanic and Atmospheric Administration. The ERL represents chemical concentrations below which adverse biological effects were rarely observed.

RESULTS and DISCUSSION

Particle Size Distribution

With few exceptions, fine to medium sands comprised the overall composition of sediments surrounding the SBOO in 2004 (**Table 4.2**, **Figure 4.2**). Generally, stations located farther offshore and southward of the SBOO had coarser sediments than those located inshore and to the north of the outfall. Most stations offshore and southward of the SBOO had sediments consisting of relatively coarse particles (≥0.3 mm or ≤2.0 phi). The remaining stations located along the shallower 19 and 28-m contours and towards the mouth of San Diego Bay had finer sediments (<0.2 mm or >2.0 phi). The higher silt content at these latter stations is probably due to sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay (see City of San Diego 1988, 2003c). This pattern was evident even though the sediments at many sites varied in the proportion of shell hash, red relict sand, fine sand, and silt.

Sorting coefficients (standard deviation) in the area surrounding the SBOO were mostly 1.0 phi or less (Table 4.2). Generally, such low values are indicative of moderately sorted to well sorted sediments (i.e., sediments composed of similarly sized particles) and are suggestive of strong wave and current activity within an area (see Gray 1981). In contrast, sorting coefficients above 1.0 phi indicate poorly sorted sediments (i.e., particles of varied sizes) and low wave and current activity. Stations I28 and I29 had sorting coefficients of approximately 2.0 phi for both surveys indicating poorly sorted sediments. Sediment observations for both stations indicate that sediments are composed of materials with multiple origins

Table 4.2

Summary of particle size parameters and organic loading indicators at SBOO stations during 2004. Data are expressed as annual means. CDF=cumulative distribution functions (see text); NA=not available. MDL=method detection limit. Pre=pre-discharge values (1995–1998). Post=post discharge values (1999–2003). Sediment observations are from combined infauna and chemistry grab observations.

	Mean Phi	SD Phi	Mean mm	Coarse %	Sand %	Fines %	Sulfides ppm	TN WT%	TOC WT%	Sediment Observations
CDF							NA	0.051	0.748	
MDL							0.14	0.005	0.010	
19 m stations										
I35	3.7	1.2	0.078	0.0	65.6	34.3	15.20	0.035	0.285	sand/silt
I34	0.9	1.6	0.565	15.8	81.0	0.7	0.50	0.012	0.052	Fine sand/shell hash
I31	3.1	0.7	0.119	0.0	91.8	8.0	0.45	0.019	0.133	Sandy silt
I23	3.1	0.8	0.116	0.4	89.3	10.1	0.91	0.048	0.103	Coarse sand/coarse black sand/shell hash
I18	3.1	0.9	0.115	0.1	87.2	12.2	1.14	0.018	0.146	Fine sand/silt
I10	3.0	0.9	0.121	0.3	90.1	9.3	1.61	0.016	0.133	Silt/sand
I4	1.0	0.8	0.477	7.1	92.2	0.6	0.00	0.005	0.054	Fine sand/sand/silt/shell hash
28 m stations										
I33	2.9	1.0	0.131	0.3	89.3	10.2	5.80	0.031	0.232	Fine silty sand
I30	3.2	0.8	0.104	0.1	85.4	14.2	2.17	0.024	0.176	Fine sand/silt
I27	3.2	0.9	0.109	0.2	86.9	12.9	0.84	0.020	0.147	Fine sand/silt
I22	2.7	1.1	0.151	0.1	89.2	10.2	4.23	0.023	0.157	Fine sand/silt
I14	3.2	0.8	0.107	0.1	86.2	13.6	3.91	0.026	0.189	Fine sand/silt
I15	2.9	1.3	0.135	0.1	84.9	13.8	14.19	0.023	0.181	Fine sand/silt
I16	2.5	0.9	0.171	0.1	93.7	5.8	5.07	0.019	0.144	Fine sand/silt/coarse black sand/shell hash
I12	1.9	1.0	0.273	3.3	93.3	3.3	0.85	0.006	0.074	Fine sand/silt/coarse black sand/shell hash
I9	3.2	1.0	0.105	0.3	84.2	15.4	19.42	0.026	0.212	Fine sand/silt
I6	1.4	1.3	0.354	6.8	86.4	6.6	0.51	0.011	0.084	Red relict sand/shell hash
I2	1.5	0.8	0.345	4.6	95.1	0.3	0.00	0.005	0.063	Fine sand
I3	0.9	0.7	0.532	10.5	88.4	0.0	0.00	0.005	0.050	Fine sand/red relict sand
38 m stations										
I29	2.7	2.2	0.176	11.7	65.0	20.8	0.62	0.023	0.211	Fine sand/coarse black sand/red relict sand
I21	0.9	0.7	0.526	8.2	90.8	1.0	0.47	0.006	0.053	Red relict sand
I13	1.1	1.0	0.466	7.4	89.5	1.4	0.00	0.004	0.055	Red relict sand/sand/shell hash
I8	1.3	0.8	0.426	6.6	91.9	1.4	0.29	0.005	0.064	Fine sand, sand/silt
55 m stations										
I28	2.5	2.1	0.179	10.7	62.3	26.9	0.62	0.040	0.365	Fine sand/silt/coarse black sand/gravel
I20	1.1	1.6	0.455	11.9	82.0	3.4	0.41	0.004	0.038	Red relict sand
I7	0.7	0.7	0.602	12.5	87.2	0.1	0.00	0.005	0.052	Red relict sand
I1	2.8	1.0	0.149	0.6	91.3	8.1	0.00	0.024	0.179	Fine sand/silt
Area Means										
2004	2.3	1.1	0.263	4.4	85.9	9.1	2.93	0.018	0.135	
Post	2.4	0.8	0.241	1.8	89.2	8.9	2.22	0.017	0.133	
Pre-	2.6	0.8	0.215	1.4	87.7	10.2	4.59	0.019	0.143	

such as coarse black sand, fine sand, and red relict sand. For example, coarse black sand has been found in disturbed areas and near dredge disposal sites (see City of San Diego 2003a), and red relict sand was deposited during the Pleistocene epoch (Emery, 1960). Station I28 is located northeast of a dredge disposal site and appears to be affected by anthropogenic activities. Mean particle size for the South Bay generally has increased in coarseness since 1995 as indicated by area means for pre-discharge, post-discharge, and the 2004 survey (Table 4.2). Particle size began to increase during 1998 when El Niño conditions produced storms that reduced the levels of fine sediments along the San Diego coastline (City of San Diego 2003b). Average particle size

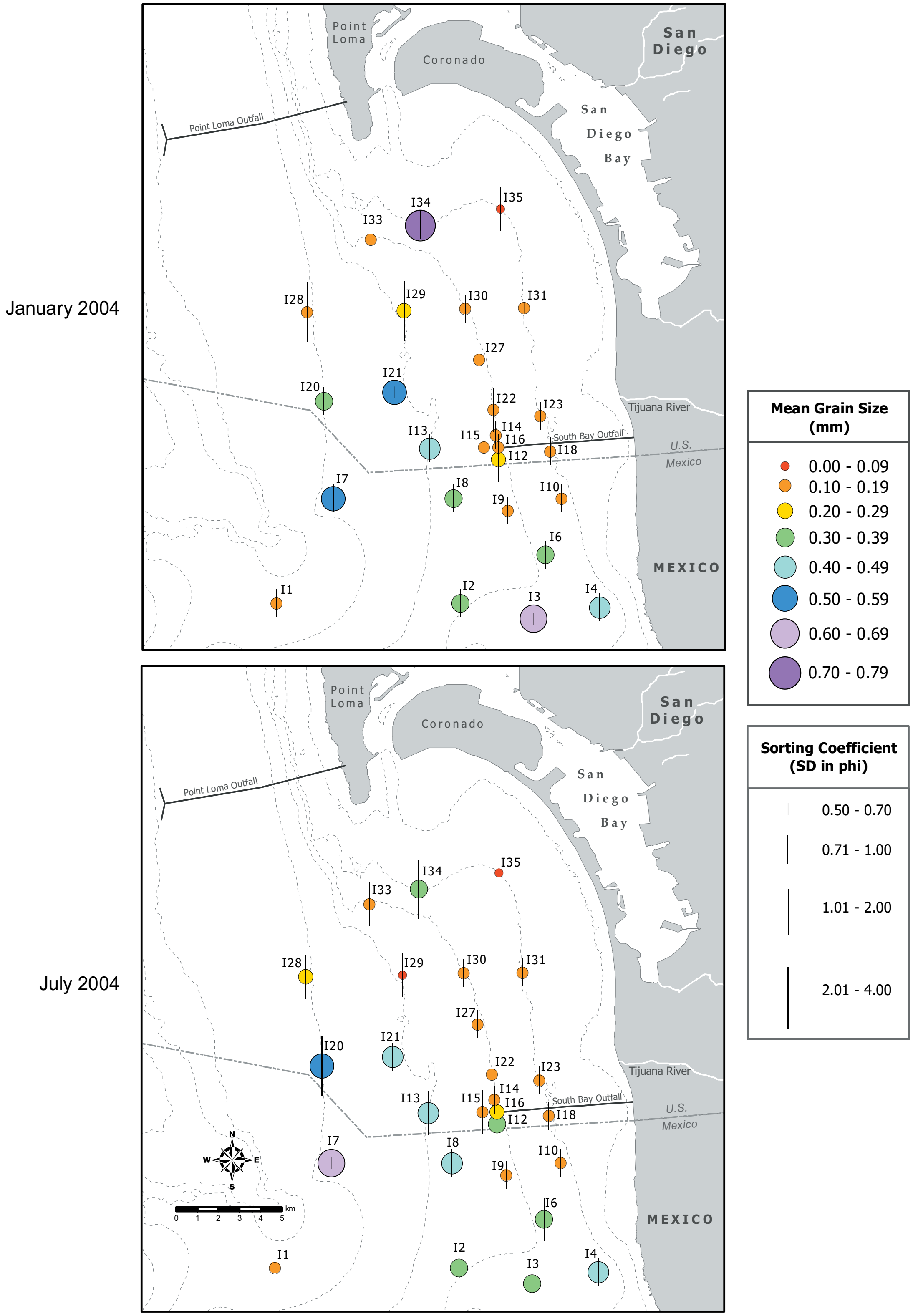

Figure 4.2

Comparison of January and July surveys for differences in sediment particle size distribution for SBOO sediment chemistry stations sampled during 2004. Mean particle size is based on diameter in millimeters, and sorting coefficient (standard deviation) is in phi units.

was 0.215 mm (2.6 phi) during the 1995–1998 period, and has steadily increased to 0.263 mm (2.3 phi) in 2004. The gradual change in particle size may be partially attributed to the drought conditions that persisted in San Diego from 1999 through much of 2004. These conditions resulted in a reduction of runoff from rivers and bays causing a decrease in deposition of terrestrial fine particles onto the ocean shelf.

There were few differences in particle size distribution between the January and July 2004 surveys (Figure 4.2). The greatest change in sediment particles occurred at stations I34 and I3 where mean particle size differed by over 0.3 mm (**Appendix B.2**). These stations contained variable amounts of coarse materials between surveys such as fine sand vs. shell hash at I34 and fine sand vs. red relict sand at I3 (Table 4.2). In addition, station I34 is located near the channel that enters San Diego Bay, and may be occasionally affected by dredging. Variable amounts of red relict sand were also present at stations I20 and I29 and coarse black sand was found at I29. This resulted in particle size differences of approximately 0.2 mm between surveys for both stations.

Indicators of Organic Loading

The average concentrations of total organic carbon and total nitrogen in South Bay sediments in 2004 were similar to those of previous surveys (**Figure 4.3**). Concentrations of both parameters were below median values for the Southern California Bight (Table 4.2). The highest average values for these indicators were found at stations I9, I28, I29, I33, and I35, and correspond to high concentrations of fine sediments (fines) at these sites. This is not unexpected, since particle size is known to be a factor affecting concentrations of organic parameters (Emery 1960, Eganhouse and Venkatesan 1993).

Mean sulfide values ranged from zero to 19.42 ppm, however the mean value at most stations was less than 1.0 ppm and only slightly higher than the MDL. The highest values occurred at stations I9, I15, and I35 where sediments consisted of relatively high levels of percent fines. The average sulfide values in 2004 were higher than the post-discharge years but lower than those prior to discharge. Overall, there was no pattern in concentrations of organic loading indicators relative to wastewater discharge.

Trace Metals

Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, tin, and zinc were frequently detected in South Bay area sediments in 2004 (**Table 4.3**). In contrast, thallium was detected relatively infrequently, while selenium was not detected at all. The use of more sensitive instrumentation starting in late 2003 increased the detection frequency for several of these metals, specifically antimony, lead, and silver (see Methods and Materials).

Generally, there was no pattern in trace metal contamination related to proximity to the SBOO. Stations with sediments consisting of greater amounts of fine particles (e.g., I9, I29, I35) had higher concentrations of metals. However, the highest concentrations of arsenic occurred where sediments consisted of very coarse red relict sand (i.e., stations I6, I7, I13, and I21). Despite a general increase in mean concentrations of aluminum, antimony, cadmium, iron, lead, manganese, tin, and zinc in 2004 relative to previous surveys, trace metal concentrations in the SBOO sediments were generally low compared to the median values for southern California. Moreover, all trace metal concentrations were below the ERL sediment quality thresholds.

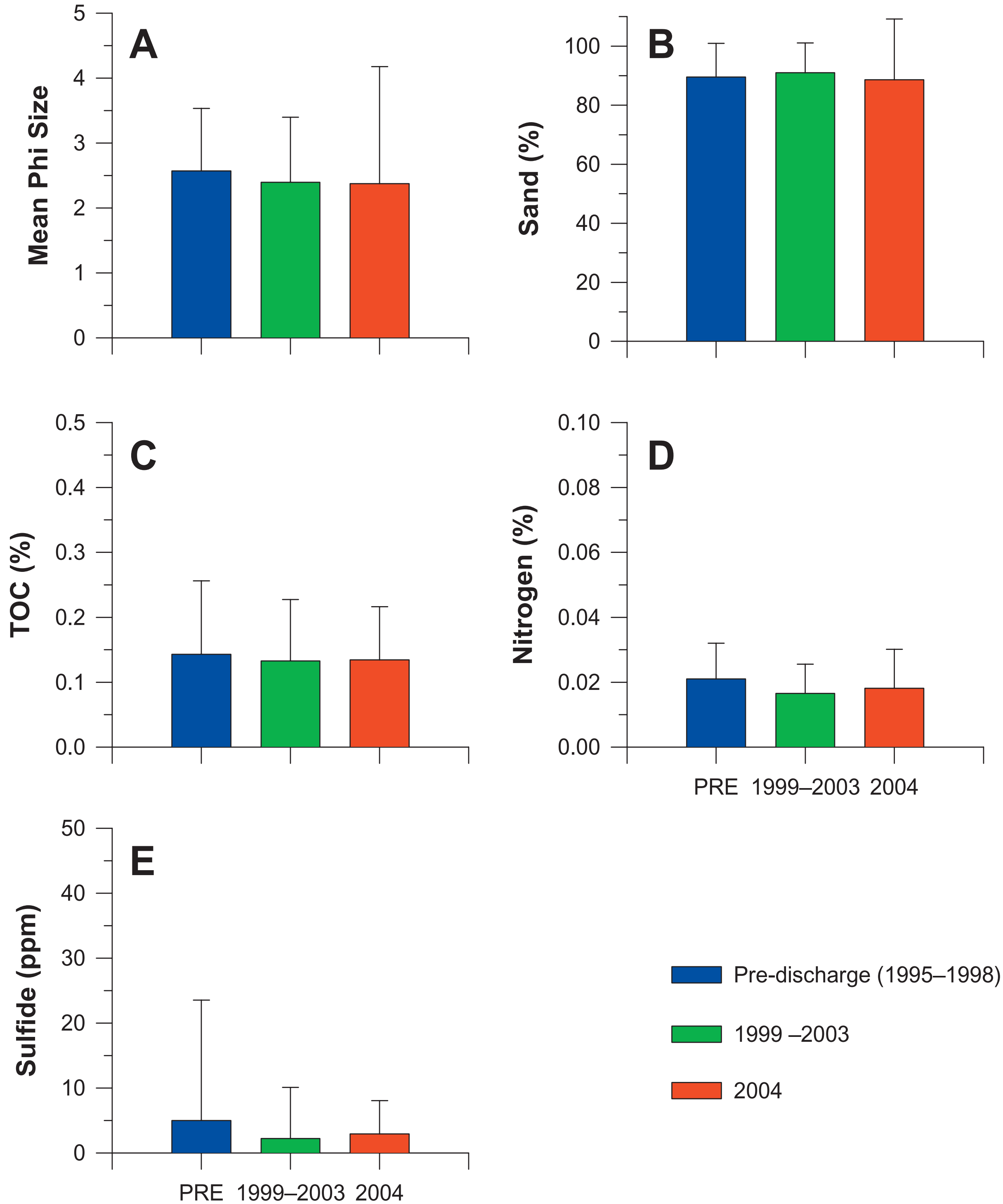

Figure 4.3

Comparison of values for several sediment quality parameters surrounding the SBOO in 2004 with values during previous post-discharge monitoring (1999–2003) and the pre-discharge period (1995–1998): (A) mean phi size; (B) percent sand; (C) percent total organic carbon (TOC); (D) percent total nitrogen; (E) sulfides (ppm). Data are expressed as area wide means for each survey period. Error bars represent one standard deviation.

Table 4.3

Concentrations of trace metals (parts per million) detected at each station during 2004. CDF=cumulative distribution function (see text). MDL=method detection limit. ERL TV=Effects Range Low Threshold Value. NA=not available. Pre=pre-discharge values (1995–1998). Post=post discharge values (1999–2003). Values that exceed the median CDF are indicated in bold type. See Appendix A.1 for metal names represented by the periodic table symbols.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Ag	Tl	Sn	Zn
MDL	1.15	0.13	0.33	0.002	0.001	0.01	0.016	0.028	0.75	0.142	0.004	0.003	0.036	0.013	0.022	0.059	0.052
CDF	9400	0.2	4.80	na	0.26	0.29	34.0	12.0	16800	na	na	0.040	na	0.17	na	na	56.0
ERL	na	na	8.2	na	na	1.2	81	34	na	46.7	na	0.2	20.9	1.0	na	na	150
19 m Stations																	
I35	**11065**	**0.5**	2.40	48.65	0.17	0.12	16.6	5.8	13500	4.70	199.0	0.023	5.5	nd	nd	1.6	33.2
I34	2083	nd	1.41	8.00	0.06	0.04	4.0	0.9	3640	2.36	71.7	0.006	1.0	0.08	0.21	1.2	6.9
I31	6965	**0.2**	1.27	19.50	0.12	0.10	11.9	1.4	10220	0.84	260.7	0.005	2.3	**0.22**	nd	1.9	17.9
I23	9005	**0.9**	1.49	37.70	0.15	0.11	15.8	2.4	12990	1.10	318.1	nd	3.3	nd	nd	2.1	24.5
I18	**10580**	**1.2**	1.80	53.10	0.17	0.12	19.8	3.4	15255	1.13	328.2	0.002	4.3	0.05	nd	2.2	27.6
I10	**9585**	**0.2**	1.55	38.15	0.14	0.08	14.6	3.2	10980	1.89	208.9	0.002	3.9	nd	0.20	1.5	22.1
I4	1775	**0.2**	1.56	4.84	0.01	0.03	5.5	0.9	3490	1.57	69.6	0.002	1.1	0.02	nd	0.8	5.8
28 m Stations																	
I33	5900	**0.2**	1.75	25.15	0.10	0.07	9.6	3.1	7325	3.41	107.8	0.015	2.8	nd	nd	1.3	17.6
I30	**11925**	**0.2**	1.87	35.05	0.15	0.11	15.5	3.5	10955	2.02	178.2	0.005	4.1	nd	nd	1.6	23.9
I27	**11045**	**0.3**	1.42	37.55	0.15	0.09	14.6	3.5	10910	2.09	180.9	0.006	3.9	nd	nd	1.5	23.2
I22	7245	**0.2**	1.60	24.00	0.12	0.10	12.2	2.3	9165	1.83	180.4	0.005	3.1	nd	nd	1.6	17.9
I14	**10355**	**0.2**	1.89	43.75	0.15	0.10	14.7	3.8	10990	1.95	175.5	0.004	4.3	nd	nd	1.7	23.3
I15	8080	**0.3**	2.39	33.85	0.13	0.07	13.9	2.9	9760	3.00	155.1	0.005	3.8	nd	0.18	1.3	21.5
I16	8065	**0.2**	1.33	27.70	0.13	0.11	12.8	4.1	11380	1.71	260.6	0.002	2.8	nd	nd	2.0	21.1
I12	4415	0.1	1.33	19.40	0.04	0.06	7.9	1.7	5800	1.24	87.0	nd	1.8	nd	nd	1.0	12.7
I9	**12590**	**0.3**	1.53	48.10	0.17	0.10	17.4	4.3	12360	2.59	197.1	0.005	5.3	nd	0.16	1.6	27.6
I6	2920	**0.4**	4.08	9.65	0.02	0.06	9.3	1.2	5670	1.81	54.4	0.002	1.5	0.02	nd	1.0	7.9
I2	1575	**0.2**	0.73	2.42	0.02	0.04	5.7	0.6	1705	1.13	26.6	0.003	0.8	0.03	0.13	0.8	3.5
I3	1550	0.1	1.33	2.44	0.01	0.05	6.1	0.5	2970	0.90	65.0	0.002	0.8	0.07	nd	0.9	4.3
38 m Stations																	
I29	**10660**	**0.5**	2.55	33.03	0.17	0.08	15.9	4.1	11940	3.16	170.7	0.011	4.2	0.03	nd	1.7	23.7
I21	2234	**0.4**	**7.46**	3.70	0.07	0.06	11.9	0.7	8890	3.45	35.4	0.003	0.8	0.02	nd	0.7	7.7
I13	1835	0.1	**4.99**	3.77	0.03	0.07	10.4	0.8	6640	2.45	71.2	nd	0.9	0.02	nd	0.9	7.1
I8	2370	**0.2**	2.06	4.75	0.04	0.04	8.5	0.9	4560	1.59	42.1	0.002	1.1	0.03	nd	0.8	7.7
55 m Stations																	
I28	8800	**1.7**	2.38	31.30	0.16	0.10	13.6	5.3	10420	4.29	140.6	0.021	5.8	0.01	nd	1.8	24.1
I20	2265	**0.2**	2.57	4.38	0.07	0.02	5.6	0.8	4735	1.99	24.0	0.002	1.0	0.02	nd	0.8	6.6
I7	1790	**0.2**	4.37	2.80	0.03	0.06	9.7	0.5	8160	2.15	81.6	0.002	0.8	0.14	nd	0.9	8.2
I1	4350	0.1	1.10	13.40	0.09	0.12	9.9	1.9	7450	2.36	174.4	0.031	3.0	0.01	0.11	1.4	13.5
Area Means																	
2004	6334	0.4	2.23	22.82	0.10	0.08	11.6	2.4	8587	2.17	143.1	0.007	2.7	0.05	0.17	1.4	16.3
Post	4589	0.1	2.44	18.36	0.16	0.06	9.1	4.1	5869	0.27	53.1	0.003	1.4	0.15	0.5	0.04	12.6
Pre-	5164	0.1	2.47	na	0.12	0.003	10.2	2.6	6568	0.09	47.4	0.003	1.9	0.00	0.20	0.0	12.5

Pesticides

A single chlorinated pesticide was detected in three sediment samples collected during 2004 (**Appendix B.3**). The DDT derivative, p,p-DDE, was found at stations I15 (480 ppt), I28 (700 ppt), and I29 (1650 ppt) during July. These values were lower than the median CDF value of 1250 ppt for this pesticide, and significantly lower than the ERL of 3890 ppt. Station I28 has had elevated pesticide levels in the past, which have been periodically associated with dredge disposal materials (see City of San Diego 2001, 2002a, b).

PCBs and PAHs

PCBs were not detected during 2004, while low levels of 17 PAH compounds were detected at all stations (Appendix B.3). The PAH values were near or below MDL levels and well below the ERL of 1684 ppt for total PAH. The detection of low levels of PAHs at all stations appears to reflect a change in methodology where values below MDLs can be reliably estimated with qualitative identification via a mass spectrophotometer (see Methods and Materials).

The highest PAH concentrations were found at stations I10, I27, and I33. Station I33 is located next to the boat channel outside the mouth of San Diego Bay, and I27 is in line with the channel (see Figure 3.1). Station I10 is a shallow station located just south of the SBOO.

SUMMARY and CONCLUSIONS

Overall, sediment conditions surrounding the South Bay Ocean Outfall (SBOO) in 2004 were similar to previous years with the exception of a slight increase in overall particle size. Moreover, there was no indication of contaminant footprints surrounding the SBOO based on analyses of particle size or sediment chemistry data.

Sediments at the South Bay sampling sites consisted primarily of fine to medium sands in 2004 with an average particle size of 0.263 mm (2.3 phi). This represents the result of a steady increase in particle size from an average of 0.215 mm (2.6 phi) observed prior to wastewater discharge (1995–1998). This relative increase in coarser sediments may be partially attributed to the loss of fine particles during storms produced by the El Niño events of 1998. Additionally drought conditions that followed and continued through much of 2004 have likely led to reduced replenishment of fine particles in coastal sediments by terrestrial runoff.

Spatial patterns in sediment composition within the SBOO region may be partially attributed to the multiple geological origins of red relict sands, shell hash, coarse sands, and other detrital sediments (Emery 1960). Stations located offshore and southward of the SBOO consisted of very coarse sediments. In contrast, stations located in shallower water and north of the outfall towards the mouth of San Diego Bay had finer sediments. Sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay probably contributes to the higher content of silt at these stations (see City of San Diego 1988). Generally, the low sediment sorting coefficients suggest that relatively strong currents in the region may affect sediment composition at the sample sites.

Concentrations of organic indicators and trace metals were relatively low in South Bay sediments compared to the entire southern California continental shelf (see Schiff and Gossett 1998). Higher concentrations of organic compounds and most trace metals were generally associated with finer sediments. This pattern is consistent with that found in other studies, in which the accumulation of fine particles has been shown to greatly influence the organic and metal content of particles (e.g., Eganhouse and Venkatesan 1993). The detection frequency of several trace metals increased in 2004 relative to previous surveys, but these changes are likely related to the use of a more sensitive instrument that began in late 2003. Generally, trace metal concentrations in the SBOO sediments were low compared to the median values for southern California, and all were below the ERL sediment quality thresholds. Other sediment contaminants were rarely detected during 2004. For example, PCBs were not detected at any stations, and only one derivative of the pesticide DDT was detected at three stations. Although PAHs were found at a low concentration at all stations this was at least partly the result of a change in methodology and the increased reporting of estimated values. The highest concentrations of PAHs were found at two stations either near the San Diego Bay entrance channel, and at a station located in shallow water just south of the SBOO. Overall, there was no pattern in sediment contaminant concentrations relative to the SBOO.

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Chapter 5. Macrobenthic Communities

INTRODUCTION

Along the coastal shelf of southern California, benthic macroinvertebrates that live within or on the surface of the sediments (i.e., infauna and epifauna, respectively), represent a diverse faunal community (Fauchald and Jones 1979, Thompson et al. 1993a, Bergen et al. 2001). These animals are important members of the marine ecosystem, serving vital functions in wide ranging capacities. Some species decompose organic material as a crucial step in nutrient cycling, other species filter suspended particles from the water column, thus affecting water clarity. Many species of benthic macrofauna also are essential prey for fish and other organisms.

Human activities that impact the benthos can sometimes result in toxic contamination, low levels of oxygen, or other forms of environmental degradation. Certain macrofaunal species are highly sensitive to such changes and rarely occur in impacted areas. Others are opportunistic and can thrive under altered conditions. Since various species respond differently to environmental stress, macrobenthic assemblages have become valuable indicators of anthropogenic impact (Pearson and Rosenberg 1978, Warwick 1993, Smith et al. 2001). Consequently, the assessment of benthic community structure is a major component of many marine monitoring programs, which document both existing conditions and trends over time.

The structure of benthic communities is influenced by many factors including sediment conditions (e.g., particle size and sediment chemistry), water conditions (e.g., temperature, salinity, dissolved oxygen, and current velocity), and biological factors (e.g., food availability, competition, and predation). For example, benthic assemblages on the coastal shelf off San Diego typically vary along gradients in particle size and depth. However, both human activities and natural processes can influence the structure of invertebrate communities in marine sediments. Therefore, in order to determine whether changes in community structure are related to human impacts, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the SBOO discharge area and the San Diego region in general (e.g., City of San Diego 1999, 2000).

This chapter presents analyses and interpretations of the macrofaunal data collected at fixed stations surrounding the SBOO during 2004. Included are descriptions and comparisons of soft-bottom macrofaunal assemblages in the area, and analysis of benthic community structure.

MATERIALS and METHODS

Collection and Processing of Samples

Benthic samples were collected during January and July, 2004 at 27 stations surrounding the SBOO (**Figure 5.1**). These stations range in depth from 18 to 60 m and are distributed along four main depth contours. Listed from north to south along each contour, these stations include: (1) 19-m contour: stations I35, I34, I31, I23, I18, I10, I4; (2) 28-m contour: stations I33, I30, I27, I22, I14, I16, I15, I12, I9, I6, I2, I3; (3) 38-m contour: stations I29, I21, I13, I8; (4) 55-m contour: stations I28, I20, I7, I1.

Samples for benthic community analysis were collected from two replicate 0.1-m^2 van Veen grabs per station during the January survey. During the July survey, two replicate grabs were collected for only eight stations (I1, I8, I9, I12, I13, I15, I28,

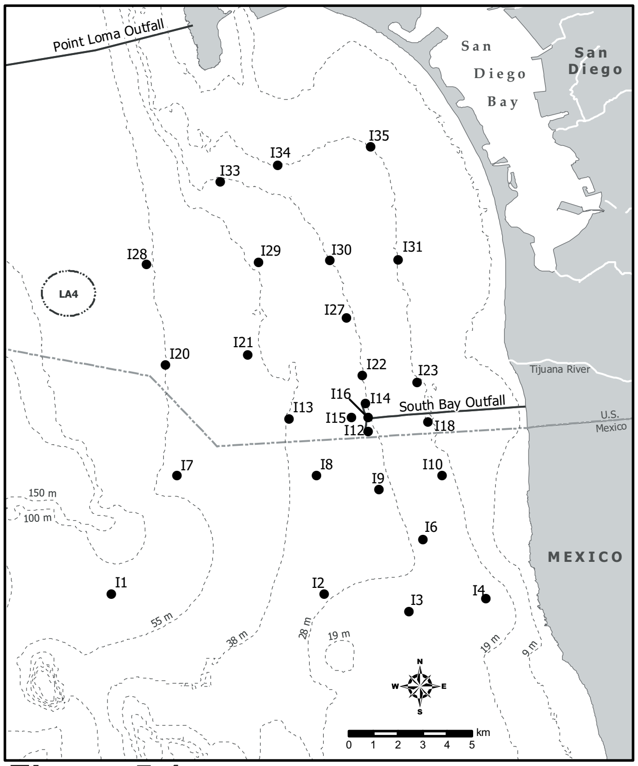

Figure 5.1
Macrobenthic station locations, South Bay Ocean Outfall Monitoring Program.

and I30) due to regulatory relief for a mandated sediment mapping study (see Chapter 1). One replicate grab was collected at the remaining 19 stations. A separate grab was collected at each station for analysis of sediment quality (see chapter 4). The criteria established by the United States Environmental Protection Agency (USEPA) to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0-mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego 2004a). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into major taxonomic groups by a subcontractor. Biomass was measured as the wet weight in grams per sample for each of the following taxonomic categories: Annelida (mostly polychaetes), Arthropoda (mostly crustaceans), Mollusca, Ophiuroidea, non-ophiuroid Echinodermata, and other miscellaneous phyla combined (e.g., Chordata, Cnidaria, Nemertea, Platyhelminthes, Phoronida, Sipuncula). Values for ophiuroids and all other echinoderms were later combined to give a total echinoderm biomass. After biomassing, all animals were identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

Data Analyses

The following community structure parameters were calculated for each station: species richness (mean number of species per 0.1-m^2 grab), annual total number of species per station, abundance (mean number of individuals per grab), biomass (mean grams per grab, wet weight), Shannon diversity index (mean H' per grab), Pielou's evenness index (mean J' per grab), Swartz dominance (mean minimum number of species accounting for 75% of the total abundance in each grab), Infaunal Trophic Index (mean ITI per grab) (see Word 1980), and Benthic Response Index (mean BRI per grab) (see Smith et al. 2001).

Multivariate analyses were performed using PRIMER v5 (Plymouth Routines in Multivariate Ecological Research) software to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling (MDS). The macrofaunal abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination. Analyses were run on individual grab samples and on the mean of the two replicate grabs per station-survey. Differences in results were considered negligible; thus for clarity and simplicity, results presented herein are for mean abundances of replicate grabs per station-survey. Patterns in the distribution of macrofaunal assemblages were compared to environmental variables by overlaying the physico-chemical data onto MDS plots based on the biotic data (see Field et al. 1982).

Table 5.1

Benthic community parameters at SBOO stations sampled during 2004. Data are expressed as annual means for: species richness, no. species/0.1 m^2 (SR); total cumulative no. species for the year (Tot Spp); abundance/0.1 m^2 (Abun); biomass, g/0.1 m^2; diversity (H'); evenness (J'); Swartz dominance, no. species comprising 75% of a community by abundance (Dom); benthic response index (BRI); infaunal trophic index (ITI).

	N	SR	Tot spp	Abun	Biomass	H'	J'	Dom	BRI	ITI
19 m stations										
I-35	3	65	118	172	4.6	3.9	0.93	29	24	79
I-34	3	39	86	207	4.1	2.7	0.76	9	3	78
I-31	3	56	116	265	2.3	3.0	0.74	14	16	75
I-23	3	73	159	854	6.2	3.3	0.76	18	15	73
I-18	3	44	87	129	1.8	3.1	0.81	14	11	74
I-10	3	42	84	138	2.9	3.2	0.86	16	15	85
I-4	3	37	78	105	10.4	3.1	0.86	15	4	77
28 m stations										
I-33	3	78	154	233	2.3	3.9	0.90	31	22	82
I-30	4	54	125	136	1.0	3.5	0.88	22	22	80
I-27	3	64	131	176	1.8	3.7	0.90	26	23	79
I-22	3	51	108	174	3.8	3.1	0.80	17	20	76
I-14	3	61	113	200	1.6	3.4	0.82	20	21	78
I-16	3	72	158	213	10.9	3.4	0.81	26	20	79
I-15	4	51	115	215	3.2	2.5	0.64	12	16	73
I-12	4	69	154	273	2.4	3.2	0.76	20	20	77
I-9	4	83	181	365	3.0	3.2	0.73	20	25	78
I-6	3	42	78	201	9.4	2.8	0.75	11	11	73
I-2	3	47	90	235	1.8	2.4	0.63	10	12	71
I-3	3	48	93	228	12.9	2.9	0.74	12	10	72
38 m stations										
I-29	3	95	199	430	3.3	3.7	0.82	31	16	85
I-21	3	41	88	239	2.9	2.6	0.71	9	6	93
I-13	4	56	129	316	6.4	2.9	0.72	13	12	86
I-8	4	56	129	245	4.2	2.9	0.73	14	14	77
55 m stations										
I-28	4	135	270	405	4.4	4.3	0.89	52	9	80
I-20	3	63	121	251	5.4	3.4	0.84	20	12	87
I-7	3	67	136	270	2.8	3.5	0.84	20	8	87
I-1	4	52	133	160	1.0	3.1	0.80	18	15	75
All stations										
Mean		61	127	253	4.3	3.2	0.79	19	15	79
Min		37	78	105	1.0	2.4	0.63	9	3	71
Max		135	270	854	12.9	4.3	0.93	52	25	93

RESULTS and DISCUSSION

Community Parameters

Number of Species

A total of 719 macrobenthic taxa were identified during 2004. Of these, 30% represented rare or unidentifiable taxa that were recorded only once. The average number of taxa per 0.1 m^2 grab ranged from 37 to 135, and the cumulative number of taxa per station ranged from 78 to 270 (**Table 5.1**). This wide variation in species richness is consistent with previous years, and can probably be attributed to different habitat types in the area (see City of San Diego 2004b). Higher numbers of species, for example, are common at stations such as I28 and I29 where sediments are finer than most other SBOO sites (see Chapter 4). In addition, species richness varied between surveys, averaging about 17% higher in July than in January (see **Figure 5.2**). Although species richness varied both spatially and temporally, there were no apparent patterns relative to distance from the outfall.

Polychaete worms made up the greatest proportion of species, accounting for 34–55% of the taxa at various sites during 2004. Crustaceans composed 14–31% of the species, molluscs from 13 to 24%, echinoderms from 2 to 11%, and all other taxa combined about 5–18%. These percentages are generally similar to those observed during previous years, including prior to discharge (e.g., see City of San Diego 2000, 2004b).

Macrofaunal Abundance

Macrofaunal abundance ranged from a mean of 105 to 854 animals per grab in 2004 (Table 5.1). The greatest number of animals occurred at stations I9, I13, I23, I28, and I29, which were the only sites that averaged over 300 individuals per sample. Station I28 is typically characterized by high abundance, with a variety of different taxa accounting for the high numbers (see City of San Diego 2004b). In contrast, high abundances at station I23 primarily were due to large numbers of nematodes and several species of polychaetes (i.e., *Hesionura coineaui difficilis*, *Pisione remota*, and *Saccocirrus* sp) Overall, abundance values were within the range of historical variation (Figure 5.2), and there were no clear spatial patterns relative to the outfall.

Similar to past years, polychaetes were the most abundant animals in the region, accounting for 38–77% of the different assemblages during 2004. Crustaceans averaged 3–33% of the animals at a station, molluscs from 3 to 26%, echinoderms from <1 to 13%, and all remaining taxa about 2–30% combined.

Biomass

Total biomass averaged from 1.0 to 12.9 grams per 0.1 m^2 (Table 5.1). High biomass values are often due to the collection of large motile organisms such as sand dollars, sea stars, crabs, and snails. For example, during 2004 a single specimen of the echinoid *Lovenia cordiformis* weighed 21.5 grams, accounting for over 60% of the annual biomass at station I3, and over 13% of the biomass for all stations during the July survey. Although these large animals introduced considerable variability, overall biomass at the SBOO stations during the year was similar to historical values (Figure 5.2).

Overall, polychaetes accounted for 4–77% of the biomass at a station, crustaceans 2–38%, molluscs 5–85%, echinoderms <1–80%, and all other taxa combined 1–37%. In the absence of large individual molluscs or echinoderms, polychaetes dominated most stations in terms of biomass.

Species Diversity and Dominance

Species diversity (H') varied during 2004, ranging from 2.4 at station I2 to 4.3 at I28 (Table 5.1). Average diversity in the region generally was similar to previous years (Figure 5.2), and no patterns relative to distance from the outfall were apparent. The relatively wide range of evenness values (0.63–0.93) also reflects the dominance of a few species at some of the SBOO stations. Most sites with evenness values below the mean (0.79) were dominated by polychaetes with the exception of I23, with the single most dominant taxa being nematodes (not identified beyond phylum). The spatial patterns in evenness were similar to those for diversity.

Species dominance was measured as the minimum number of species accounting for 75% of a community by abundance (see Swartz 1978). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low index values indicate communities dominated by few species. Values at individual stations varied widely, averaging from 9 to 52 species per station during the year (Table 5.1). Dominance values for 2004 were

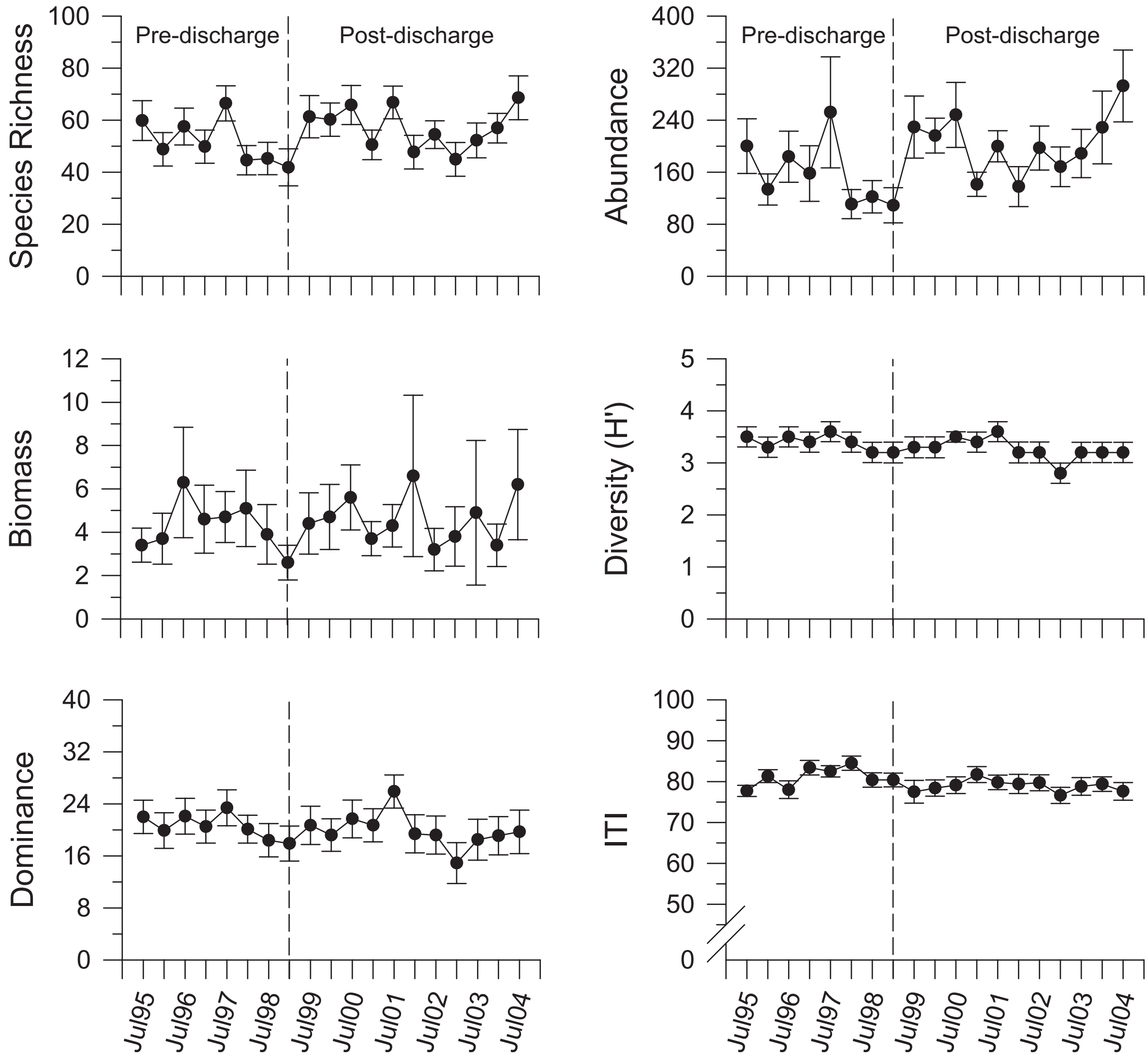

Figure 5.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall (1995–2004). Species Richness=number of species; Abundance=number of animals; Biomass=grams, wet weight; Diversity=Shannon diversity index (H'); Dominance=Swartz dominance index; ITI=infaunal trophic index. Data are expressed as means per $0.1m^2$ grab pooled over all stations for each survey (n=54). Error bars represent 95% confidence limits.

similar to historical values (Figure 5.2). No clear patterns relative to the outfall were evident in dominance values.

Environmental Disturbance Indices

The benthic response index (BRI) during 2004 averaged from 3 to 25 at the various SBOO stations (Table 5.1). Index values below 25 (on a scale of 100) suggest undisturbed communities or "reference conditions," while those in the range of 25–33 represent "a minor deviation from reference condition," which may or may not reflect anthropogenic impact (Smith et al. 2001). Station I9 had the highest BRI, and was the only station at the upper limit for reference conditions. There were no patterns in BRI relative to distance from the outfall, and index values at sites nearest the discharge did not suggest significant environmental disturbance.

The infaunal trophic index (ITI) averaged from 71 to 93 at the various sites in 2004 (Table 5.1). There were no patterns with respect to the outfall, and all values at sites near the discharge were

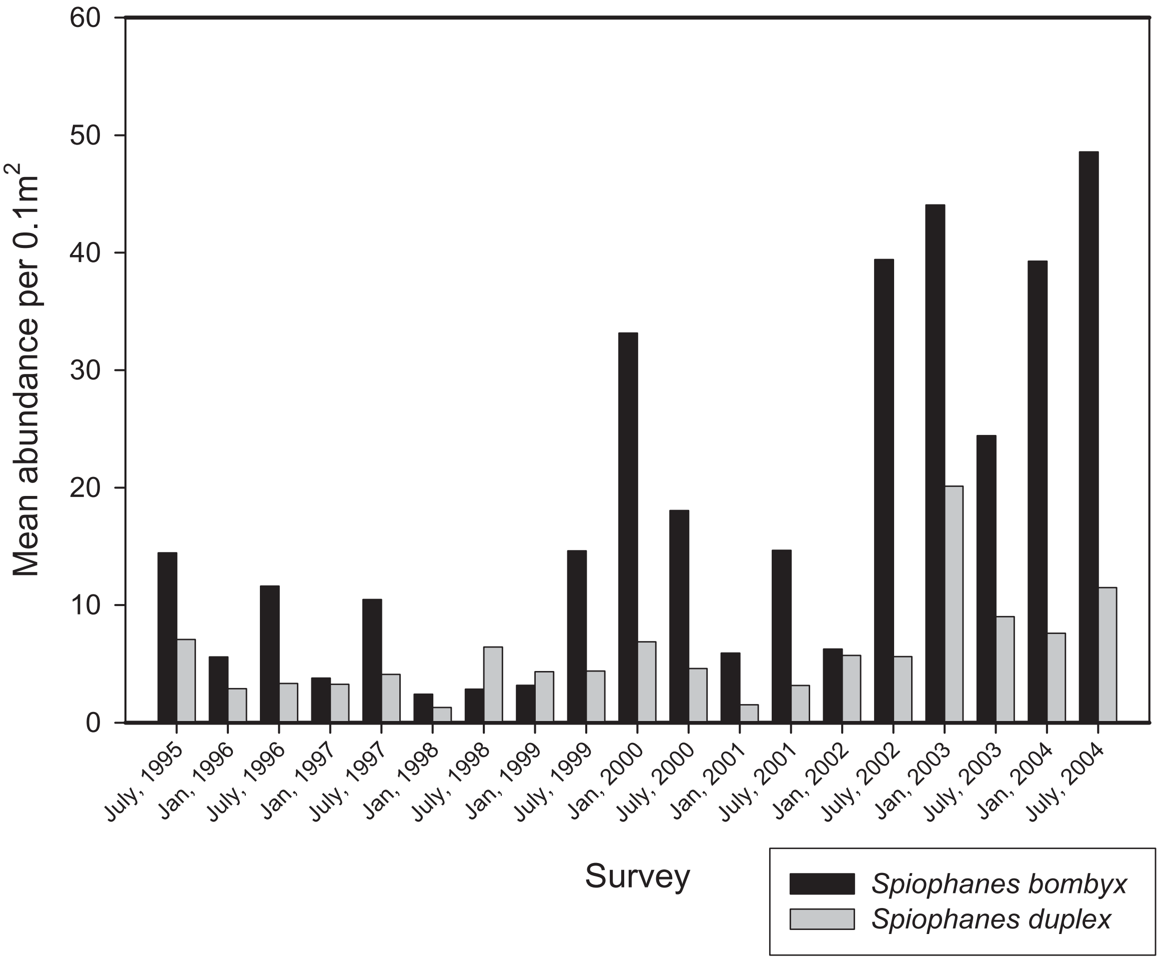

Figure 5.3
Mean abundance per 0.1 m^2 grab of the common polychaetes *Spiophanes bombyx* and *Spiophanes duplex*, for each survey at the SBOO benthic stations from July 1995 to July 2004.

characteristic of undisturbed sediments (i.e., ITI >60, Word 1980). In addition, average ITI over all sites has changed little since monitoring began (see Figure 5.2).

Dominant Species

Most assemblages in the SBOO region were dominated by polychaete worms. For example, the list of dominant fauna in **Table 5.2** includes 18 polychaetes, three crustaceans, one nemertean, and nematodes (not identified beyond phylum).

The spionid polychaete *Spiophanes bombyx* was the most numerous and the most ubiquitous species, averaging about 44 worms per sample and occurring in 100% of the samples. A closely related species, *S. duplex*, was fifth in total abundance. Together, these two species accounted for over 19% of all individuals collected during 2004. Both were found in higher numbers than some past years (**Figure 5.3**). The second most abundant taxa were nematode worms (not identified to species) and the third most abundant was the sabellid polychaete, *Euchone arenae*.
Polychaetes comprised nine of the ten most abundant species per occurrence. Several polychaete species were found in high numbers at only a few stations (e.g., *Pareurythoe californica, Saccocirrus* sp, and *Eulalia levicornuta*). Few macrobenthic species were widely distributed, and of these only *Spiophanes bombyx*, *Ampelisca cristata cristata*, and *Sigalion spinosus* occurred in more than 80% of the samples. Only four of the most frequently

Table 5.2

Dominant macroinvertebrates at the SBOO benthic stations sampled during 2004. Included are the 10 most abundant species overall, the 10 most abundant per occurrence, and the 10 most frequently collected (or widely distributed) species. Abundance values are expressed as mean number of individuals per 0.1 m^2 grab sample. MAS=mean abundance per sample; MAO=mean abundance per occurrence; PA=percent of total abundance; FO=frequency of occurrence (%).

Species	Higher taxa	MAS	MAO	PA	FO
Most Abundant					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. Nematoda	Nematoda	12.7	22.9	4.8	56
3. *Euchone arenae*	Polychaeta: Sabellidae	9.9	24.3	3.7	41
4. *Monticellina siblina*	Polychaeta: Cirratulidae	7.4	13.8	2.8	54
5. *Spiophanes duplex*	Polychaeta: Spionidae	7.2	9.5	2.7	76
6. Euclymeninae sp A	Polychaeta: Maldanidae	5.3	8.3	2.0	63
7. *Ampelisca cristata cristata*	Crustacea: Amphipoda	4.5	5.6	1.7	82
8. *Euphilomedes carcharodonta*	Crustacea: Ostracoda	4.0	6.8	1.5	59
9. *Lanassa venusta venusta*	Polychaeta: Terebellidae	3.7	16.7	1.4	22
10. *Mooreonuphis* sp SD 1	Polychaeta: Onuphidae	3.5	14.6	1.3	24
Most Abundant per Occurrence					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. *Saccocirrus* sp	Polychaeta: Saccocirridae	2.4	43.7	0.9	6
3. *Pareurythoe californica*	Polychaeta: Amphinomidae	0.6	34.0	0.2	2
4. *Eulalia levicornuta*	Polychaeta: Phyllodocidae	1.0	26.5	0.4	4
5. *Euchone arenae*	Polychaeta: Sabellidae	9.9	24.3	3.7	41
6. Nematoda	Nematoda	12.7	22.9	4.8	56
7. *Hesionura coineaui difficilis*	Polychaeta: Phyllodocidae	3.0	20.1	1.1	15
8. *Pisione remota*	Polychaeta: Pisionidae	2.6	19.9	1.0	13
9. *Odontosyllis* sp SD 1	Polychaeta: Syllidae	0.7	19.0	0.3	4
10. *Chloeia pinnata*	Polychaeta: Amphinomidae	1.9	17.2	0.7	11
Most Frequently Collected					
1. *Spiophanes bombyx*	Polychaeta: Spionidae	43.9	43.9	16.6	100
2. *Ampelisca cristata cristata*	Crustacea: Amphipoda	4.5	5.6	1.7	82
3. *Sigalion spinosus*	Polychaeta: Sigalionidae	2.4	3.0	0.9	82
4. *Spiophanes duplex*	Polychaeta: Spionidae	7.2	9.5	2.7	76
5. *Spiochaetopterus costarum*	Polychaeta: Chaetopteridae	1.9	2.5	0.7	74
6. *Hemilamprops californicus*	Crustacea: Cumacea	2.2	3.1	0.8	72
7. Maldanidae †	Polychaeta: Maldanidae	2.0	3.1	0.8	67
8. *Glycinde armigera*	Polychaeta: Goniadidae	1.7	2.6	0.6	67
9. Euclymeninae sp A	Polychaeta: Maldanidae	5.3	8.3	2.0	63
10. *Carinoma mutabilis*	Nemertea: Anopla	2.5	3.9	0.9	63

† = unidentified juveniles and/or damaged specimens

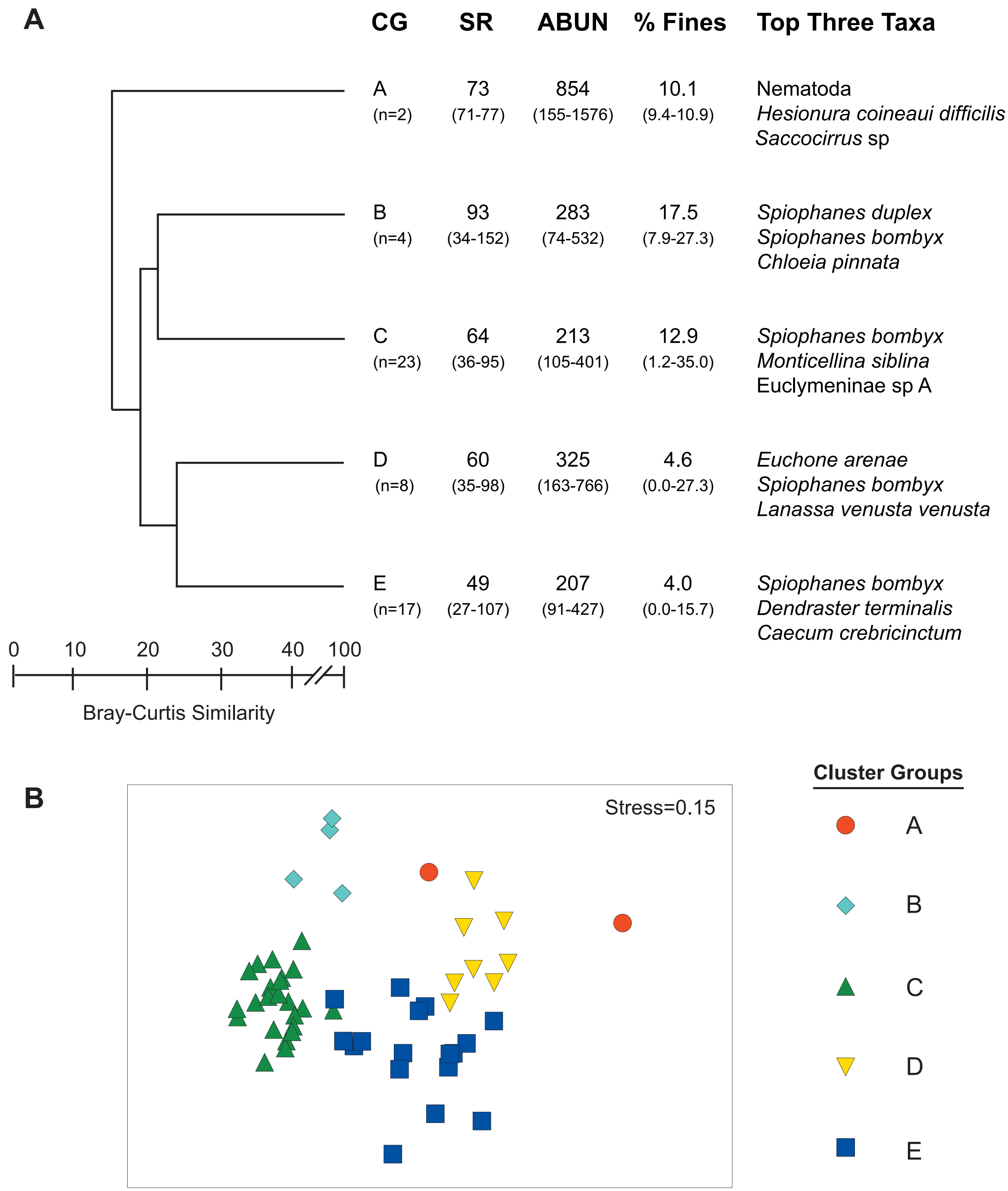

Figure 5.4

(A) Cluster results of macrofaunal abundance data for the SBOO benthic stations sampled during 2004. CG=cluster group; SR=mean number of species; ABUN=mean number of individuals. Ranges in parentheses are for individual grab samples. **(B)** MDS ordination of SBOO benthic stations sampled during 2004. Plot based on square-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.

collected species were also among the top ten taxa in terms of abundance (i.e., *S. bombyx*, *Ampelisca cristata cristata*, *S. duplex*, and *Euclymeninae* sp A).

Multivariate Analyses

Classification analysis discriminated between five habitat-related benthic assemblages (cluster groups A–E) during 2004 (**Figure 5.4A**). These assemblages differed in terms of their species composition, including the specific taxa present and their relative abundances. The dominant species composing each group are listed in **Table 5.3**. A MDS ordination of the station/survey entities confirmed the validity of cluster groups A–E (Figure 5.4B). These analyses identified no significant patterns regarding proximity to the discharge (**Figure 5.5**).

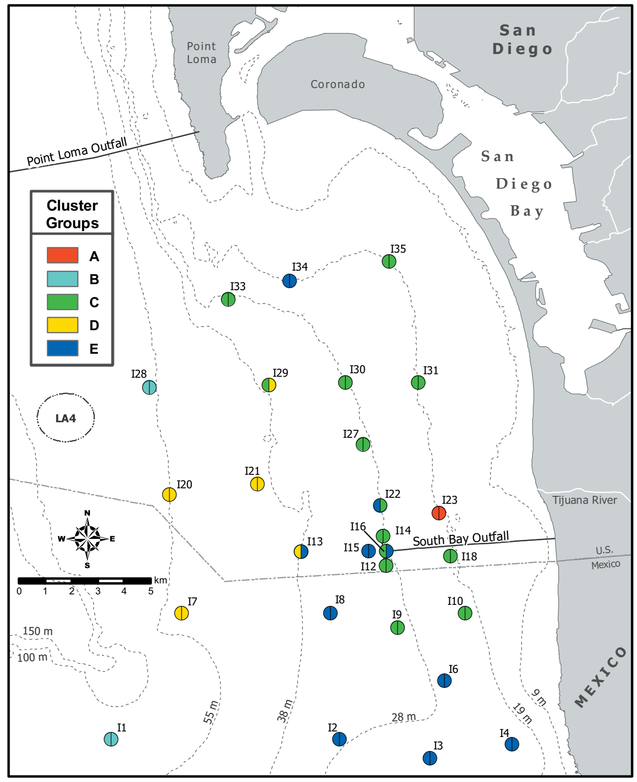

Figure 5.5
SBOO benthic stations sampled during January and July 2004, color-coded to represent affiliation with benthic cluster groups. Left half of circle represents cluster group affiliation for the January survey; right half represents the July survey.

Cluster group A represented the January and July survey from a single station (I23) located on the 19-m depth contour. Sediments at this site were characterized by a relatively low percentage of fine particles. The group A assemblage was somewhat unique for the region; it was dominated by nematode worms and some relatively abundant uncommon polychaete species. Many of the dominant polychaetes from this group were absent from, or occurred in much lower numbers at the other SBOO stations (e.g., *Hesionura coineaui difficilis*, *Saccocirrus* sp, *Pisione remota*).

Cluster group B comprised two stations located along the 55-m depth contour. Sediments at these deepwater sites contained a relatively high percentage of fine particles (**Figure 5.6**). The group B assemblage was characterized by high species richness and abundance, averaging 93 taxa and 283 individuals per grab (Figure 5.4A). The three most abundant species were the spionid polychaetes *Spiophanes bombyx* and *S. duplex* and the amphinomid polychaete *Chloeia pinnata*. The following polychaetes were also characteristic of this assemblage, but relatively uncommon in other groups: the oweniid *Myriochele gracilis*, the paraonid *Aricidea (Acmira) simplex*, and the sigalionid *Sthenelanella uniformis* (Table 5.3). The ophiuroid *Amphiodia urtica*, typically found at this depth, also was abundant in this assemblage.

Cluster group C included sites primarily located along the 19 and 28-m depth contours, and where sediments also contained relatively high amounts of fine particles. This assemblage averaged 64 taxa and 213 individuals per 0.1 m^2. The dominant species in this group were *Spiophanes bombyx* and *S. duplex*, the cirratulid *Monticellina siblina*, and the maldanid *Euclymeninae* sp A.

Cluster group D comprised two stations characterized by coarse relict red sand sediments located along the 55-m depth contour and three stations along the 38-m contour. In contrast to the other deeper-water assemblage described above (group B), this group had fewer taxa but more individual organisms per grab. The polychaetes

Table 5.3

Summary of the most abundant taxa composing cluster groups A–E from the 2004 survey of SBOO benthic stations. Data are expressed as mean abundance per sample (no./0.1m^2) and represent the ten most abundant taxa in each group. Values for the three most abundant species in each cluster group are in bold. n=number of station/survey entities per cluster group

		Cluster Group				
		A	B	C	D	E
Species/Taxa	Taxa	(n=2)	(n=4)	(n=23)	(n=8)	(n=17)
Ampelisca cristata cristata	Crustacea	1.5	1.1	5.3	6.8	3.6
Amphiodia urtica	Echinodermata	—	4.6	0.1	0.1	0.5
Apionsoma misakianum	Sipuncula	3.0	3.9	—	8.9	0.1
Aricidea (*Acmira*) *simplex*	Polychaeta	—	4.5	0.1	0.7	—
Axiothella rubrocincta	Polychaeta	0.3	—	1.7	1.4	4.3
Cadulus aberrans	Mollusca	—	2.0	3.2	0.1	0.5
Caecum crebricinctum	Mollusca	0.3	0.1	—	2.9	**4.8**
Carinoma mutabilis	Nemertea	0.8	0.4	2.4	0.1	4.4
Chloeia pinnata	Polychaeta	11.0	**11.1**	—	4.5	0.1
Chone veleronis	Polychaeta	0.3	0.1	5.0	—	0.6
Cirriformia sp SD2	Polychaeta	20.0	—	0.1	0.5	0.1
Dendraster terminalis	Echinodermata	0.8	—	—	0.7	**4.9**
Euchone arenae	Polychaeta	55.3	0.6	0.1	**46.8**	2.8
Euclymeninae sp A	Polychaeta	5.0	1.3	**11.1**	0.2	0.7
Eulalia levicornuta	Polychaeta	26.5	—	—	—	—
Euphilomedes carcharodonta	Crustacea	0.5	7.3	5.0	0.3	4.2
Eusyllis sp SD2	Polychaeta	0.8	—	—	7.0	0.3
Hesionura coineaui difficilis	Polychaeta	**74.8**	—	0.1	0.8	0.3
Lanassa venusta venusta	Polychaeta	—	0.3	0.1	**24.8**	0.1
Leptochelia dubia	Crustacea	0.8	5.3	0.9	3.1	3.4
Monticellina siblina	Polychaeta	—	3.8	**16.3**	0.2	0.6
Mooreonuphis sp	Polychaeta	—	—	0.1	10.1	2.9
Mooreonuphis sp SD1	Polychaeta	—	—	—	21.2	1.2
Myriochele gracilis	Polychaeta	—	6.5	—	—	0.1
Nematoda	Nematoda	**221.8**	3.8	0.5	22.9	1.9
Odontosyllis sp SD1	Polychaeta	19.0	—	—	—	—
Onuphidae	Polychaeta	—	0.5	0.2	9.0	1.7
Ophelia pulchella	Polychaeta	0.3	—	—	0.9	3.6
Photis californica	Crustacea	—	5.0	—	0.5	—
Pisione remota	Polychaeta	58.8	—	0.1	2.6	—
Protodorvillea gracilis	Polychaeta	19.5	—	0.1	1.9	3.4
Saccocirrus sp	Polychaeta	**65.3**	—	—	0.1	—
Sigalion spinosus	Polychaeta	3.8	1.3	3.5	2.6	1.1
Solamen columbianum	Mollusca	—	1.9	—	2.0	3.4
Spiophanes bombyx	Polychaeta	4.5	**18.5**	**33.8**	**33.2**	**73.4**
Spiophanes duplex	Polychaeta	1.0	**31.3**	10.0	2.5	0.7
Sthenelanella uniformis	Polychaeta	—	9.8	0.6	—	0.1
Syllis (*Typosyllis*) sp SD1	Polychaeta	6.3	—	—	11.4	0.1
Syllis (*Typosyllis*) sp SD2	Polychaeta	20.5	—	0.1	0.4	0.6
Tellina modesta	Mollusca	1.0	—	3.9	0.1	0.6

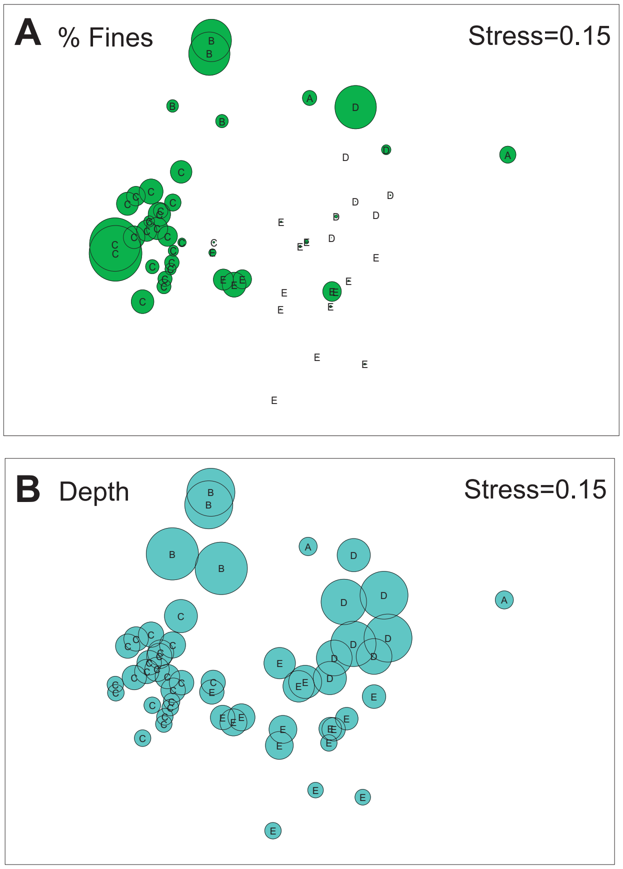

Figure 5.6
MDS ordination of SBOO benthic stations sampled during January and July 2004. Cluster groups A–E are superimposed on station/surveys. Percentage of fine particles in the sediments **(A)** and station depth **(B)** are further superimposed as circles that vary in size according to the magnitude of each value. Plots indicate associations of benthic assemblages with habitats that differ in sediment grain size and depth.

Euchone arenae and *Spiophanes bombyx* dominated this group, followed by the terebellid polychaete *Lanassa venusta venusta.*

Cluster group E comprised sites that were located on or near the 28-m depth contour. These sites averaged a low percentage of fines, with some stations containing relict red sands. The group E assemblage averaged 49 taxa and 207 individuals per grab, the lowest among all cluster groups. *Spiophanes bombyx* was numerically dominant in this group, followed by the echinoderm *Dendraster terminalis,* and the gastropod *Caecum crebricinctum*.

SUMMARY and CONCLUSIONS

Benthic macrofaunal assemblages surrounding the South Bay Ocean Outfall were similar in 2004 to those that occurred during previous years (City of San Diego 2000, 2004). In addition, these assemblages were generally typical of those occurring in other sandy, shallow-water habitats throughout the Southern California Bight (SCB) (e.g., Thompson et al. 1987, 1993b, City of San Diego 1999, Bergen et al. 2001). For example, the two assemblages found at the majority of stations (e.g., groups C and E) contained high numbers of the spionid polychaete *Spiophanes bombyx*, a species characteristic of shallow-water environments in the SCB (see Bergen et al. 2001). These two groups represented sub-assemblages of the shallow SCB benthos that differed in the relative abundances of dominant and co-dominant species. Such differences probably reflect variation in microhabitat structure, such as the presence of a fine sediment component (i.e., group C), or coarse, relict red sands (i.e., group E). In contrast, the group B assemblage occurs in mid-depth shelf habitats that probably represent a transition between the shallow sandy sediments common in the area and the finer mid-depth sediments characteristic of much of the SCB mainland shelf (see Barnard and Ziesenhenne 1961, Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993a, b, EcoAnalysis et al. 1993, Zmarzly et al. 1994, Diener and Fuller 1995, Bergen et al. 2001). A second deeper-water assemblage (group D) occurred where relict red sands were present. Polychaetes dominated group D, including the ubiquitous spionid polychaete *S. bombyx.* Finally, the group A assemblage characteristic of station I23 was quite dissimilar from assemblages found at any other station. Nematode worms and various abundant polychaete species in these samples were not common elsewhere in the region. This assemblage is similar to that sampled previously at I23 during July 2003. Analysis of the sediment chemistry data provided no evidence to explain the occurrence of this assemblage, and the presence of these animals may reflect particular components of the sediments such as variation in microhabitats or types and amounts of shell hash or algal detritus.

Multivariate analyses revealed no clear spatial patterns relative to the outfall. Comparisons of the biotic data to the physico-chemical data indicated that macrofaunal distribution and abundance in the region varied primarily along gradients of sediment type and depth. Relatively high numbers of the spionid polychaetes *Spiophanes bombyx* and *S. duplex* were collected during 2004. However, temporal fluctuations in the populations of these taxa are similar in magnitude to those that occur elsewhere in the region and that often correspond to large-scale oceanographic conditions (see Zmarzly et al. 1994). Overall, temporal patterns suggest that the benthic community has not been significantly impacted by wastewater discharge via the SBOO. For example, the range of values for species richness and abundance during 2004 was similar to that seen in previous years (see City of San Diego 2000, 2004b). In addition, environmental disturbance indices such as the BRI and the ITI were generally characteristic of assemblages from undisturbed sediments.

Anthropogenic impacts have spatial and temporal dimensions that can vary depending on a range of biological and physical factors. Such impacts can be difficult to detect, and specific effects of the SBOO discharge could not be identified during 2004. Furthermore, benthic invertebrate populations exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, b, Otway 1995). Although some changes have likely occurred near the SBOO, benthic assemblages in the area remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf.

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Chapter 6. Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fish and megabenthic invertebrate communities have become an important focus of ocean monitoring programs throughout the world because of their proximity to potentially altered sediments. Fish and invertebrate assemblages of the Southern California Bight (SCB) mainland shelf have been sampled extensively for at least 30 years, primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of fish inhabit the SCB, while the megabenthic invertebrate fauna consists of more than 200 species (Allen 1982, Allen et al. 1998). For the region surrounding the South Bay Ocean Outfall (SBOO), the most common trawl-caught fishes include speckled sanddab, longfin sanddab, hornyhead turbot, California halibut, California lizardfish and occasionally white croaker. The common trawl-caught invertebrates include relatively large species such as sea urchins and sand dollars.

The City of San Diego has been conducting trawl surveys in the area surrounding the SBOO since 1995. These surveys were designed to monitor the effects of wastewater discharge on the local marine biota by assessing the structure and stability of the demersal fish and megabenthic invertebrate communities. This chapter presents analyses and interpretations of data collected during the 2004 trawl surveys.

MATERIALS and METHODS

Field Sampling

Trawl surveys were conducted in January, April, July, and October 2004 at seven fixed sites around the SBOO (**Figure 6.1**). These stations, SD15–SD21, are located along the 27-m isobath, and encompass an area south of Point Loma, California, USA to Punta Bandera, Baja California, Mexico. During each survey a single trawl was performed at each station using a 7.6-m Marinovich otter trawl fitted with a 1.3-cm cod-end mesh net. The net was towed for 10 minutes bottom time at a speed of about 2.5 knots along a predetermined heading. Detailed methods for locating the stations and conducting trawls are described in the City of San Diego Quality Assurance Manual (City of San Diego in prep).

Trawl catches were brought on board for sorting and inspection. All organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. For fishes,

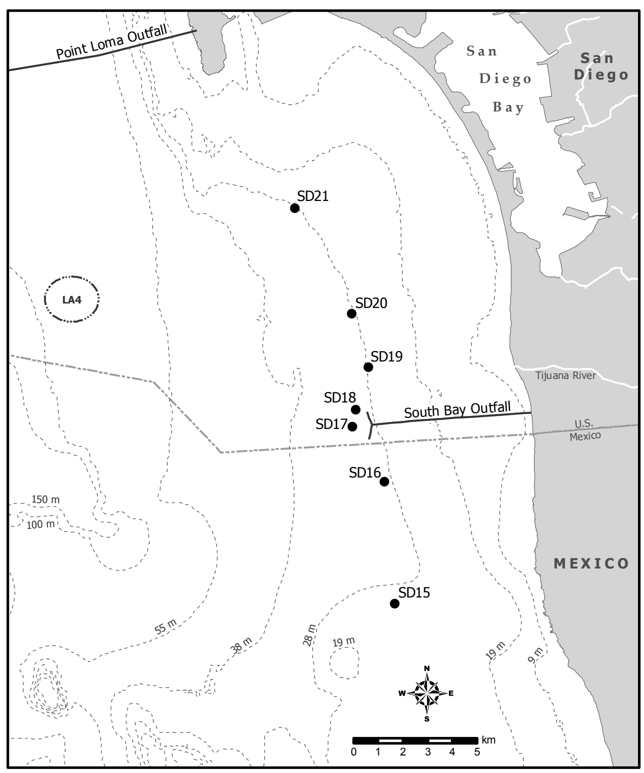

Figure 6.1
Otter trawl station locations, South Bay Ocean Outfall Monitoring Program (SD15–SD21).

Table 6.1

Demersal fish species collected in 28 trawls in the SBOO region during 2004. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per haul (MAH).

SPECIES	PA	FO	MAH	SPECIES	PA	FO	MAH
Speckled sanddab	84	100	179	Pygmy poacher	<1	18	<1
Roughback sculpin	4	82	9	Fantail sole	<1	18	<1
California lizardfish	3	89	7	Northern anchovy	<1	4	<1
Hornyhead turbot	3	96	6	Shiner perch	<1	7	<1
Yellowchin sculpin	2	57	5	White croaker	<1	4	<1
Longfin sanddab	1	57	1	Bigmouth sole	<1	4	<1
English sole	1	50	1	Curlfin sole	<1	7	<1
Plainfin midshipman	<1	50	1	Diamond turbot	<1	7	<1
Spotted turbot	<1	39	1	Calico rockfish	<1	4	<1
California scorpionfish	<1	32	1	Jack mackerel	<1	4	<1
Longspine combfish	<1	21	1	Kelp pipefish	<1	4	<1
California tonguefish	<1	36	1	Shovelnose guitarfish	<1	4	<1
California halibut	<1	36	<1	Specklefin midshipman	<1	4	<1
Pacific sanddab	<1	21	<1	Spotted cuskeel	<1	4	<1
California skate	<1	18	<1	Thornback	<1	4	<1

the total number of individuals and total biomass (wet weight, kg) were recorded for each species. Additionally, each individual fish was inspected for external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter in length according to standard protocols (see City of San Diego in prep). For invertebrates, the total number of individuals was recorded per species. Due to the small size of most organisms, invertebrate biomass was typically measured as a composite wet weight (kg) of all species combined; however, large or exceptionally abundant species were weighed separately.

Data Analyses

Populations of each fish and invertebrate species were summarized by: frequency of occurrence (number of occurrences/total number of trawls x 100); percent abundance (number of individuals/total of all individuals caught x 100); mean abundance per haul (number of individuals/total number of trawls); mean abundance per occurrence (number of individuals/number of occurrences). In addition, the following parameters were calculated for both the fish and invertebrate assemblages at each station: species richness (number of species); total abundance; Shannon diversity index (H'); total biomass. Multivariate analyses were performed on the seven stations using PRIMER (Plymouth Routines in Multivariate Ecological Research) software to examine spatio-temporal patterns in the overall similarity of fish assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking, and ordination by non-metric multidimensional scaling (MDS). The fish abundance data were square-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination.

RESULTS and DISCUSSION

Fish Community

Thirty species of fish were collected in the area surrounding the SBOO during 2004 (**Table 6.1**). The total catch for the year was 6010 individuals, representing an average of about 215 fish per trawl. The speckled sanddab comprised 84% of the total catch. This fish was the only species present in all of the hauls. Other frequently occurring fishes were California lizardfish, roughback sculpin, hornyhead turbot, yellowchin sculpin, and longfin sanddab.

Table 6.2

Summary of demersal fish community parameters for SBOO stations sampled during 2004. Data are expressed as mean and standard deviation (SD) for species richness (number of species), abundance (number of individuals), diversity (H'), and biomass (kg, wet weight); n=4.

Station	Jan	Apr	Jul	Oct	Mean	SD
Species Richness						
SD15	9	7	3	10	7	3
SD16	9	8	7	11	9	2
SD17	8	11	9	9	9	1
SD18	13	9	9	9	10	2
SD19	7	8	10	9	9	1
SD20	8	9	8	9	9	1
SD21	9	7	11	10	9	2
Mean	9	8	8	10		
SD	2	1	3	1		
Diversity						
SD15	0.6	0.6	0.1	1.4	0.7	0.6
SD16	0.4	0.8	0.5	1.0	0.7	0.3
SD17	0.6	0.8	0.7	1.2	0.8	0.3
SD18	0.7	0.7	0.9	1.0	0.8	0.2
SD19	0.4	0.5	0.5	0.6	0.5	0.1
SD20	0.9	0.4	0.4	1.0	0.7	0.3
SD21	0.8	0.6	1.0	1.3	0.9	0.3
Mean	0.6	0.6	0.6	1.1		
SD	0.2	0.1	0.3	0.3		

Station	Jan	Apr	Jul	Oct	Mean	SD
Abundance						
SD15	272	129	129	112	161	75
SD16	287	156	189	208	210	56
SD17	168	218	167	198	188	25
SD18	289	274	247	214	256	33
SD19	420	349	187	143	275	131
SD20	185	366	246	69	217	124
SD21	204	227	219	138	197	40
Mean	261	246	198	155		
SD	86	90	43	54		
Biomass						
SD15	4.0	1.5	0.9	4.5	2.7	1.8
SD16	3.0	8.7	2.2	3.6	4.4	2.9
SD17	2.9	2.3	2.1	3.1	2.6	0.5
SD18	4.0	4.0	3.8	3.0	3.7	0.5
SD19	5.4	3.6	2.7	1.6	3.3	1.6
SD20	2.9	3.4	4.9	3.5	3.7	0.9
SD21	3.2	2.7	3.7	5.3	3.7	1.1
Mean	3.6	3.7	2.9	3.5		
SD	0.9	2.3	1.3	1.2		

These common species tended to be relatively small (<17 cm in length on average, **Appendix C.1**).

Fish abundance and biomass were highly variable during 2004. Abundance ranged from 69 to 420 fish per haul (**Table 6.2**). This wide variation was partly due to large catches of speckled sanddab, which decreased steadily over the year (e.g., 1585 in January, 1487 in April, 1180 in July, and 767 in October). This is the first decline in speckled sanddabs in several years. The wide range in biomass values (0.9 to 8.7 kg per station) was generally attributable to variation in the size of the hauls or the occurrence of large individuals. For example, the heaviest catch occurred at station SD16 in April, and was due to three relatively large California halibut that weighed approximately 7 kg.

In contrast to abundance and biomass, species richness and diversity (H') varied little with relatively low values in 2004 (Table 6.2). The average number of species was 10 or less at all stations over the year, and diversity values were less than 2 at all stations. These relatively low values are likely due to the large catches of speckled sanddabs over the course of the year.

Fish community structure in this region has varied in response to population fluctuations of a few dominant species since 1996 (**Figures 6.2, 6.3**). Although species richness has remained within a small range (between 5 and 14 species per station per year), abundances have fluctuated substantially over the years (between 28 and 275 individuals per station) (Figure 6.2). This inter-annual variability primarily reflects changes in the speckled sanddab populations (Figure 6.3), but also reflects large hauls of schooling species that occur infrequently. For example, large hauls of white croaker were responsible for the high abundance at SD21 in 1996, while a large haul of northern anchovy caused the high abundance at SD16 in 2001. Overall, none of the observed

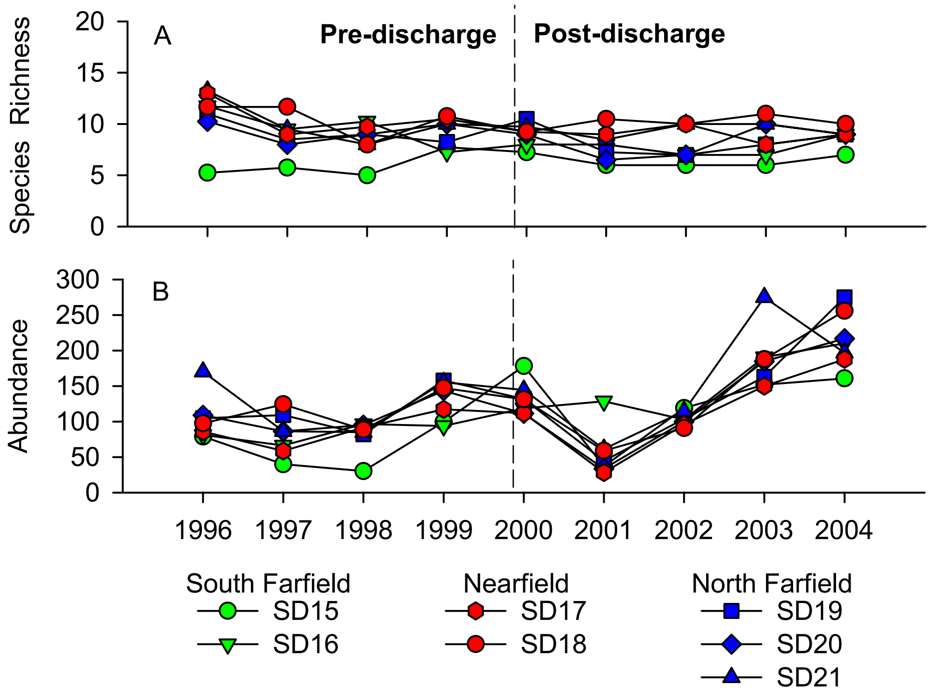

Figure 6.2
Annual mean species richness (number of species) and abundance (number of individuals) per SBOO station of demersal fish collected from 1996 through 2004.

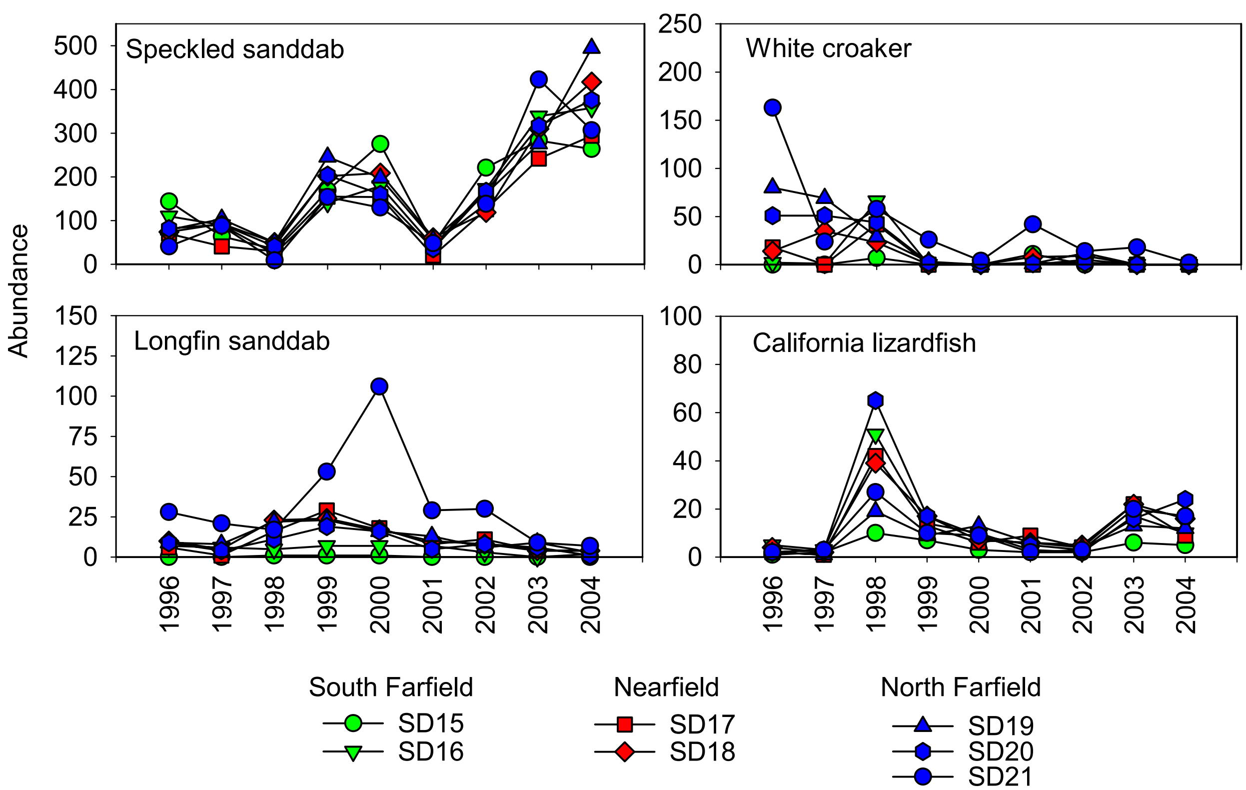

Figure 6.3
Annual mean abundance (number of individuals) per SBOO station for the four most abundant fish species collected from 1996 through 2004; n=4.

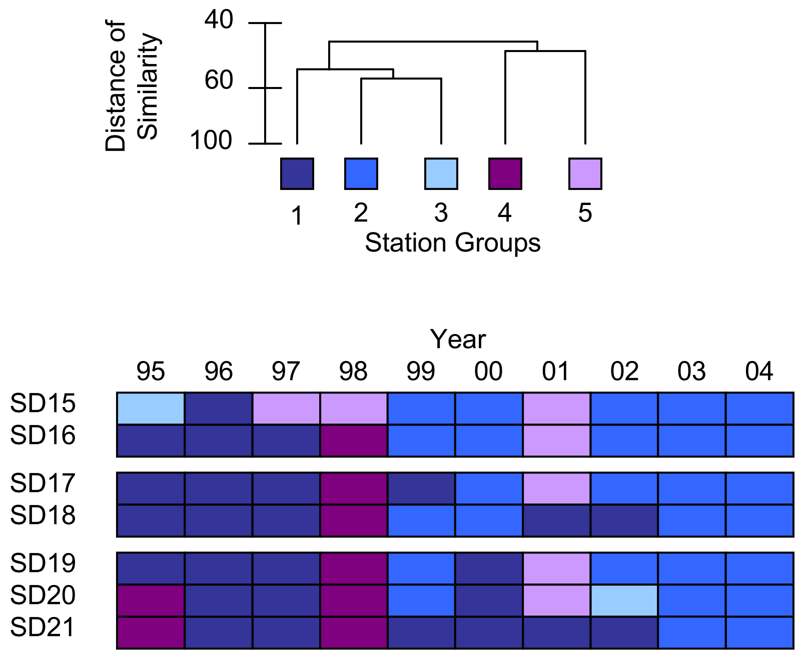

Figure 6.4
Results of classification analysis of demersal fish collected at SBOO stations SD15–SD21 between 1995 and 2004 (July surveys only). Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

changes appear to be associated with the initiation of discharge from the South Bay outfall.

Ordination and classification analyses of fish data from July surveys between 1991 and 2004 resulted in five major cluster groups (station groups 1–5) (see **Figure 6.4**). The dominant species composing each group are listed in **Table 6.3**. As with the results discussed above, these results primarily reflected different numbers of the more common species. No patterns were evident that suggest changes in the fish assemblages were associated with the initiation of the discharge.

Station group 1 comprised most stations sampled between 1995 and 1997 (Figure 6.4). The assemblage represented by this group was characterized by moderate numbers of speckled sanddabs and relatively high numbers of longfin sanddabs, California tonguefish, and hornyhead turbot (Table 6.3). Station group 2 comprised most stations sampled between 1999 and 2000 and from 2002 through 2004. This group was characterized by very high numbers of speckled sanddabs. Station group 3 comprised only two stations, SD15 and SD20 sampled in 1995 and 2000, respectively. These stations were characterized by moderate numbers of speckled sanddabs and very little else. Station groups 4 and 5 were quite different than the first three groups in having very low numbers of speckled sanddabs. They differed from each other in that station group 4 had substantially more California lizardfish, longfin sanddab, and English sole than station group 5. Also, station group 4 comprised almost all of the stations sampled in 1998 during strong El Niño conditions (NOAA-CIRES 2003), while station group 5 comprised most stations sampled in 2001.

Physical Abnormalities and Parasitism

The overall absence of fin rot or other physical abnormalities suggest that fish populations in the area continue to appear healthy. Only one physical abnormality was found during 2004; a hornyhead turbot was caught with a lesion of the eye. In addition, the overall rate of parasitism was very low (0.06%). External parasites were found on just three fish, including a single leech on each of two hornyhead turbots, as well as an eye parasite on another hornyhead turbot. In addition, the ectoparasitic isopod, *Elthusa vulgaris,* was

Table 6.3

Five most abundant and frequently occurring fish species among the five main SBOO station cluster groups. Dominant taxa (by abundance) are indicated in bold.

	SG1	SG2	SG3	SG4	SG5
Number of hauls	26	27	2	8	7
Mean no. of species per haul	9.8	6.8	3.5	8.8	6.0
Mean no. of individuals per haul	101.9	167.2	60.0	64.0	26.3
Species			**Mean Abundance**		
Speckled sanddab	**58.5**	**144.8**	**56.0**	**11.9**	**15.0**
Hornyhead turbot	**5.0**	**3.7**	**2.5**	2.6	2.0
California skate	—	—	0.5	—	—
Plainfin midshipman	—	—	0.5	—	—
Yellowchin sculpin	—	3.3	0.5	—	—
California lizardfish	—	**5.5**	—	**24.1**	**2.9**
California scorpionfish	—	—	—	—	2.0
California tonguefish	3.4	—	—	—	—
English sole	—	—	—	4.9	—
Longfin sanddab	**19.0**	**—**	—	**11.9**	—
Spotted turbot	—	2.1	—	—	2.0
White croaker	2.6	—	—	—	—

observed in several trawls. This isopod becomes detached from its host during sorting, therefore it is unknown which fish were actually parasitized. Although *E. vulgaris* occurs on a wide variety of fish species in southern California, it is especially common on sanddabs and California lizardfish, where it may reach infestation rates of 3% and 80%, respectively (Brusca 1978, 1981).

Invertebrate Community

A total of 1620 megabenthic invertebrates (about 60/trawl), representing 63 taxa, were collected during 2004 (**Appendix C.2**). The sea star, *Astropecten verrilli,* was the most abundant and most frequently captured species. This species was captured in all of the trawls and accounted for 41% of the total invertebrate catch (**Table 6.4**). Other species that occurred in at least 50% of the trawls included three crustaceans: the shrimp, *Crangon nigromaculata,* and the crabs, *Pyromaia tuberculata* and *Cancer gracilis.*

As with fish, invertebrate community parameters varied among stations and between surveys during the year (**Table 6.5**). Species richness ranged from 4 to 20 species per haul. Abundance values also varied, ranging from 12 to 170 individuals per haul. The biggest hauls were primarily high due to large numbers of *A. verrilli* and *Dendraster terminalis*, *Lytechinus pictus*, and *Philine auriformis*. Although biomass was also somewhat variable, high values generally corresponded to the collection of large species such as the sea star, *Pisaster brevispinus,* cancer crabs or sheep crabs.

Variations in megabenthic invertebrate community structure in the South Bay area generally reflect changes in species abundance (**Figure 6.5**). Although species richness has varied little (e.g., 4–14 species per station per year), abundances have fluctuated substantially, with annual values averaging between 7 and 273 individuals per station. These wide ranging abundance values generally reflect fluctuations in the populations of the dominant species, especially the echinoderms *A. verrilli*, *L. pictus*, and *D. terminalis,* as well as the shrimp *C. nigromaculata* (see **Figure 6.6**). For example, the high abundances recorded at SD17 in

Table 6.4

Megabenthic invertebrate species collected in 28 trawls in the SBOO region during 2004. Data for each species are expressed as: percent abundance (PA); frequency of occurrence (FO); mean abundance per haul (MAH).

Species	PA	FO	MAH	Species	PA	FO	MAH
Astropecten verrilli	41	100	24	*Spirontocaris prionota*	< 1	7	< 1
Philine auriformis	13	36	8	*Asterina miniata*	< 1	7	< 1
Lytechinus pictus	10	43	6	*Elthusa* sp	< 1	7	< 1
Dendraster terminalis	8	21	5	*Megastraea undosa*	< 1	7	< 1
Crangon nigromaculata	5	50	3	*Platymera gaudichaudii*	< 1	7	< 1
Pyromaia tuberculata	3	50	2	*Crangon alba*	< 1	4	< 1
Cancer gracilis	3	50	2	*Acanthodoris brunnea*	< 1	4	< 1
Ophiothrix spiculata	2	14	1	Pectinidae	< 1	4	< 1
Pisaster brevispinus	2	39	1	Polycladida	< 1	4	< 1
Kelletia kelletii	1	46	1	*Acanthodoris rhodoceras*	< 1	4	< 1
Elthusa vulgaris	1	25	< 1	*Aphrodita refulgida*	< 1	4	< 1
Heterocrypta occidentalis	1	21	1	*Calliostoma canaliculatum*	< 1	4	< 1
Crossata californica	1	21	< 1	*Cancer antennarius*	< 1	4	< 1
Hemisquilla ensigera californiensis	1	21	< 1	*Cancer jordani*	< 1	4	< 1
Pagurus spilocarpus	1	21	< 1	*Dendronotus diversicolor*	< 1	4	< 1
Heptacarpus palpator	1	11	1	*Dendronotus iris*	< 1	4	< 1
Heptacarpus stimpsoni	1	11	1	*Erileptus spinosus*	< 1	4	< 1
Loxorhynchus grandis	< 1	21	< 1	*Flabellina pricei*	< 1	4	< 1
Flabellina iodinea	< 1	14	< 1	Grapsidae	< 1	4	< 1
Randallia ornata	< 1	14	< 1	*Hermissenda crassicornis*	< 1	4	< 1
Crangon alaskensis	< 1	11	< 1	*Lophopanopeus bellus*	< 1	4	< 1
Portunus xantusii	< 1	11	< 1	*Modiolus neglectus*	< 1	4	< 1
Sicyonia ingentis	< 1	11	< 1	*Octopus* sp	< 1	4	< 1
Cancer anthonyi	< 1	11	< 1	*Paguristes bakeri*	< 1	4	< 1
Cancer sp	< 1	11	< 1	*Pagurus* sp	< 1	4	< 1
Crassispira semiinflata	< 1	11	< 1	*Pandalus platyceros*	< 1	4	< 1
Dendronotus frondosus	< 1	11	< 1	*Paraxanthias taylori*	< 1	4	< 1
Euspira lewisii	< 1	11	< 1	*Pteropurpura festiva*	< 1	4	< 1
Podochela hemphillii	< 1	7	< 1	*Pugettia producta*	< 1	4	< 1
Octopus rubescens	< 1	7	< 1	*Pycnopodia helianthoides*	< 1	4	< 1
Loxorhynchus sp	< 1	7	< 1	*Strongylocentrotus purpuratus*	< 1	4	< 1
Pachycheles pubescens	< 1	7	< 1				

1996 and SD15 in 1996 and 1997 were due to large hauls of *A. verrilli* and *L. pictus*, while the high abundances at SD15 in 2003 and 2004 were due to large hauls of *D. terminalis*. None of the observed variability in the invertebrate communities can be attributed to the initiation of discharge from the South Bay outfall.

SUMMARY and CONCLUSIONS

Speckled sanddabs once again dominated the fish assemblages surrounding the South Bay Ocean Outfall during 2004. Other fish, such as the California lizardfish, roughback sculpin, hornyhead turbot, yellowchin sculpin, and longfin sanddab, were also collected frequently. The invertebrate assemblages were also dominated by a few, prominent species. The sea star, *A. verrilli,* was the most abundant invertebrate and the shrimp, *C. nigromaculata,* and the crabs, *Pyromaia tuberculata* and *Cancer gracilis,* were also common.

As in previous years, variation in both fish and megabenthic invertebrate communities among stations and between surveys in the region was generally due to population fluctuations of the dominant species mentioned above. For example,

Table 6.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2004. Data are expressed as mean and standard deviation (SD) for species richness (number of species), abundance (number of individuals), diversity (H') and biomass (kg, wet weight); n=4.

Station	Jan	Apr	Jul	Oct	Mean	SD
Species Richness						
SD15	9	8	5	12	9	3
SD16	9	10	6	14	10	3
SD17	5	11	6	18	10	6
SD18	7	8	8	9	8	1
SD19	5	6	8	6	6	1
SD20	10	5	4	10	7	3
SD21	20	7	10	9	12	6
Mean	9	8	7	11		
SD	5	2	2	4		
Diversity						
SD15	1.2	1.2	0.6	1.6	1.1	0.4
SD16	2.0	1.8	1.0	1.6	1.6	0.4
SD17	1.4	1.3	0.9	1.4	1.2	0.2
SD18	1.4	1.7	0.9	1.8	1.4	0.4
SD19	0.9	0.8	0.6	1.0	0.8	0.2
SD20	1.9	0.6	0.5	2.1	1.3	0.9
SD21	2.4	1.8	1.6	1.8	1.9	0.3
Mean	1.6	1.3	0.9	1.6		
SD	0.5	0.5	0.4	0.4		

Station	Jan	Apr	Jul	Oct	Mean	SD
Abundance						
SD15	133	63	65	90	88	33
SD16	18	29	26	86	40	31
SD17	12	62	88	170	83	66
SD18	28	48	107	33	54	36
SD19	48	76	65	79	67	14
SD20	27	62	28	22	35	18
SD21	66	16	44	29	39	21
Mean	47	51	60	73		
SD	42	21	30	52		
Biomass						
SD15	0.7	0.3	0.6	1.4	0.8	0.5
SD16	0.8	1.0	0.2	1.1	0.8	0.4
SD17	1.2	0.6	0.2	0.7	0.7	0.4
SD18	0.4	0.1	0.3	0.4	0.3	0.1
SD19	1.1	1.0	1.0	0.1	0.8	0.5
SD20	4.9	0.8	1.5	2.0	2.3	1.8
SD21	2.7	0.2	1.2	0.7	1.2	1.1
Mean	1.7	0.6	0.7	0.9		
SD	1.6	0.4	0.5	0.6		

despite a steady drop in abundance values from January through October, speckled sanddab abundance remained substantially higher than in previous years. Overall invertebrate abundance was largely affected by changes in populations of three echinoderms: *Astropectin verrilli*, *Lytechinus pictus*, and *Dendraster terminalis*.

Demersal fish and megabenthic invertebrate communities are inherently variable, and the observed changes in community structure may be influenced by both anthropogenic and natural factors. Anthropogenic influences include inputs from such things as ocean outfalls and storm drain runoff. Natural factors may include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niño (Karinen et al. 1985). The observed changes in the assemblages were more likely due to natural factors such as those mentioned above that can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect diversity and abundance may also be due to the mobile nature of many species (e.g., schools of fish or aggregations of urchins).

Overall, the monitoring data provided no evidence that the discharge of waste water from the South Bay Ocean Outfall in 2004 affected either the fish or megabenthic invertebrate communities in the region. Despite the variable structure of these assemblages, patterns of species diversity, abundance, and biomass were similar at all stations. In addition, no changes have been found in these assemblages that correspond to the initiation of wastewater discharge. Furthermore, the absence of fin rot or other physical abnormalities on local fishes suggests that populations in the area continue to be healthy.

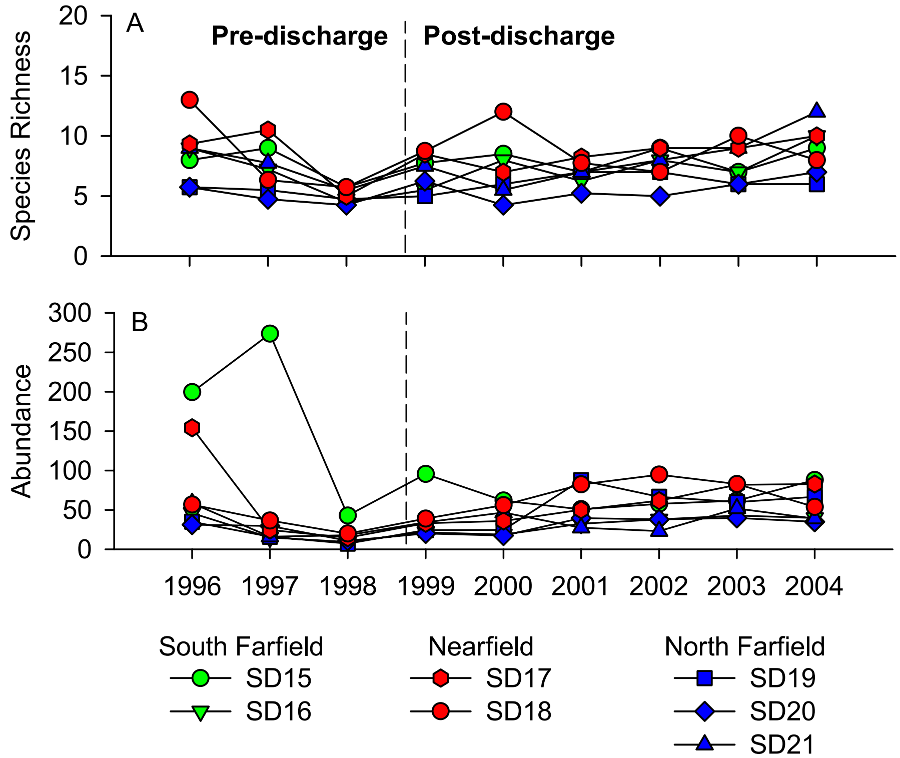

Figure 6.5
Annual mean species richness (number of species) and abundance (number of individuals) per SBOO station of megabenthic invertebrates collected from 1996 through 2004.

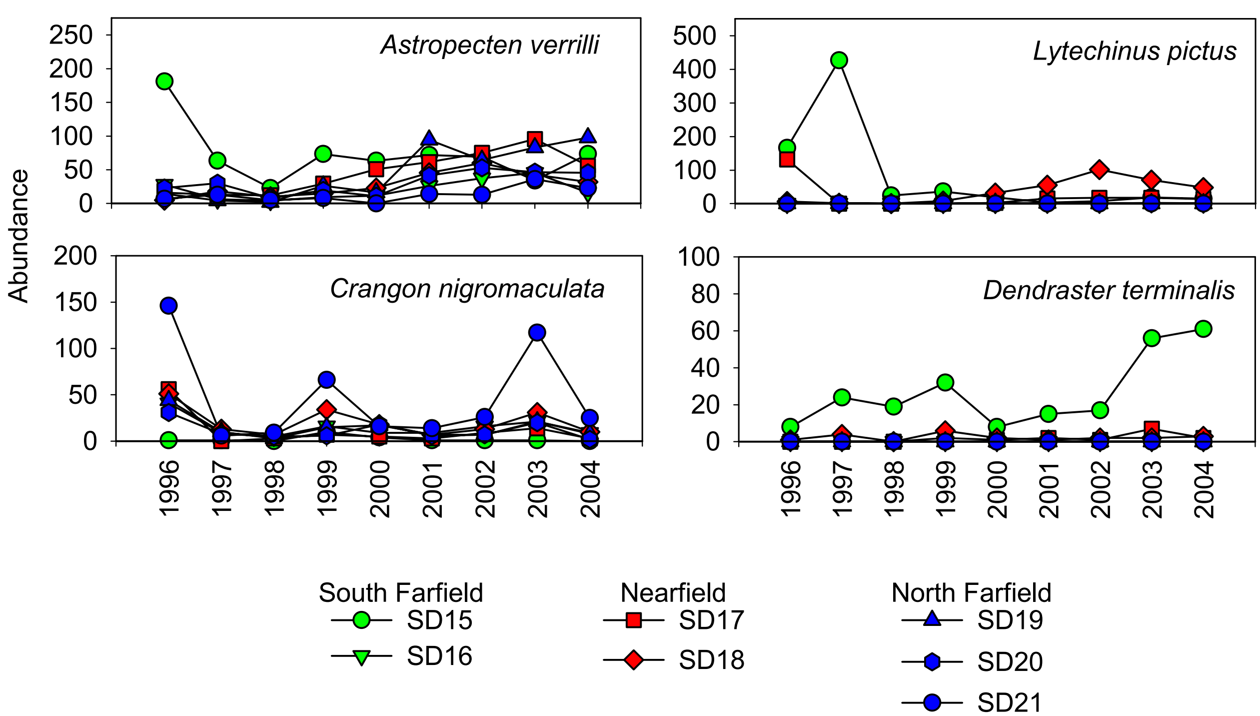

Figure 6.6
Annual mean abundance (number of individuals) per SBOO station for the four most abundant megabenthic invertebrate species collected from 1996 through 2004; n=4.

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Chapter 7. Bioaccumulation of Contaminants in Fish Tissues

INTRODUCTION

Bottom dwelling (i.e., demersal) fishes are collected as part of the South Bay Ocean Outfall (SBOO) monitoring program to assess the accumulation of contaminants in their tissues. The bioaccumulation of contaminants in a fish occurs through biological uptake and retention of chemical contaminants derived from various exposure pathways (Tetra Tech 1985). Exposure routes for demersal fishes include the adsorption or absorption of dissolved chemical constituents from the water and the ingestion and assimilation of pollutants from food sources. They also accumulate pollutants by ingesting pollutant-containing suspended particulate matter or sediment particles. Demersal fish are useful in biomonitoring programs because of their proximity to bottom sediments. For this reason, levels of contaminants in tissues of demersal fish are often related to those found in the environment (Schiff and Allen 1997).

The bioaccumulation portion of the SBOO monitoring program consists of two components: (1) liver tissues are analyzed from trawl-caught fishes; (2) muscle tissues are analyzed from fishes collected by rig fishing. Fishes collected from trawls are considered representative of the demersal fish community, and certain species are targeted based on their ecological significance (i.e., prevalence in the community). Chemical analyses are performed using livers because this is where contaminants typically concentrate due to the physiological role of the liver and the high lipid levels found there. In contrast, fishes targeted for collection by rig fishing represent a typical sport fisher's catch, and are therefore of recreational and commercial importance. Muscle tissue is analyzed from these fish because it is the tissue most often consumed by humans, and therefore the results are directly pertinent to human health.

All muscle and liver samples were analyzed for contaminants as specified in the NPDES discharge permits governing the SBOO monitoring program. Most of these contaminants are also sampled for the NOAA National Status and Trends Program. NOAA initiated the National Status and Trends Program to detect changes in the environmental quality of our nation's estuarine and coastal waters by tracking contaminants thought to be of concern for the environment (Lauenstein and Cantillo 1993). This chapter presents the results of all tissue analyses that were performed during 2004.

MATERIALS and METHODS

Collection

Fishes were collected during the April and October surveys of 2004 at seven trawl and two rig fishing stations (**Figure 7.1**). Trawl-caught fishes were collected, measured, and weighed following guidelines described in Chapter 6 of this report.

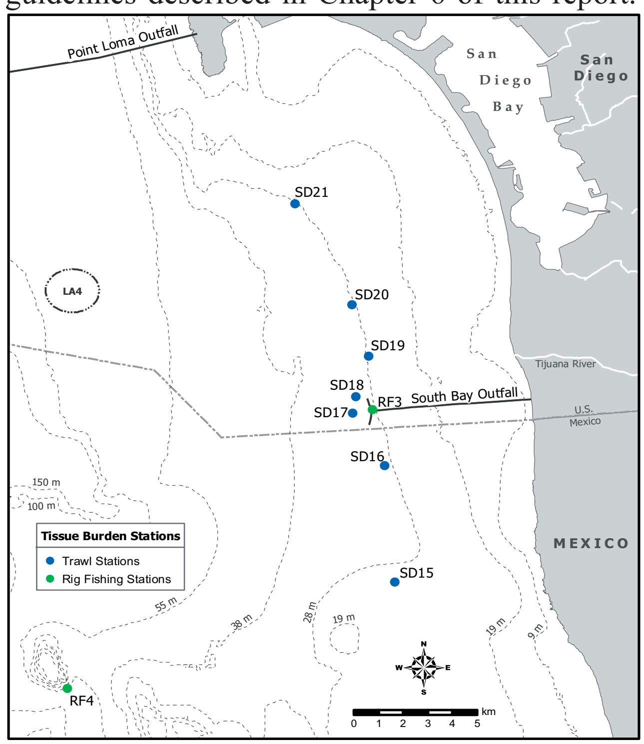

Figure 7.1
Otter trawl and rig fishing station locations for the South Bay Ocean Outfall Monitoring Program.

Table 7.1

Species collected at each SBOO trawl and rig fishing station during April and October 2004; ns=samples not collected due to insufficient numbers of fish.

Station	Rep 1	Rep 2	Rep 3
April 2004			
SD15	ns	ns	ns
SD16	Longfin sanddab	California scorpionfish	ns
SD17	Longfin sanddab	Pacific sanddab	California scorpionfish
SD18	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD19	Hornyhead turbot	ns	ns
SD20	Longfin sanddab	Hornyhead turbot	Longfin sanddab*
SD21	Hornyhead turbot	California scorpionfish	Longfin sanddab
RF3	Vermilion rockfish	Brown rockfish	Vermilion rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish
October 2004			
SD15	Hornyhead turbot	California scorpionfish	California scorpionfish
SD16	Hornyhead turbot	Hornyhead turbot	California scorpionfish
SD17	Longfin sanddab	Hornyhead turbot	Hornyhead turbot
SD18	Longfin sanddab	Hornyhead turbot	Hornyhead turbot
SD19	Hornyhead turbot	Hornyhead turbot	ns
SD20	Hornyhead turbot	California scorpionfish	California scorpionfish
SD21	Hornyhead turbot	California scorpionfish	Hornyhead turbot
RF3	Brown rockfish	Brown rockfish	Vermilion rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish

* Missing all trace metal analyses

Fishes targeted at the rig fishing sites were collected using rod and reel fishing tackle, and then measured and weighed following standard procedures (City of San Diego in prep). The species that were analyzed from each station are summarized in **Table 7.1**. The effort to collect fish at trawl stations was limited to five 10-minute trawls; occasionally, insufficient numbers of target species were obtained despite this effort. Missing samples are indicated in Table 7.1. Only fish >12 cm standard length were retained for tissue analyses. These fish were sorted into no more than three composite samples per station, each containing a minimum of three individuals. The fish were then wrapped in aluminum foil, labeled, put in ziplock bags, and placed on dry ice for transport to the Marine Biology laboratory freezer.

Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis (see City of San Diego in prep). Each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus prior to dissection. The standard length (cm) and weight (g) of each fish were recorded (**Appendix D.1**). Dissections were carried out on Teflon pads that were cleaned between samples. Tissue samples were then placed in glass jars, sealed, labeled, and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City of San Diego Wastewater Chemistry Laboratory within seven days of dissection.

All tissue samples were analyzed for the chemical constituents specified by the permit under which this sampling was performed. These trace metals, chlorinated pesticides, PCBs, and PAHs are listed in **Appendix D.2**. A summary of all parameters detected at each station during each survey is listed in **Appendix D.3**. Detected values for some parameters include those determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry), but at levels below the MDL. These were included in the data as estimated values. A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Laboratory (City of San Diego 2005).

RESULTS

Contaminants in Liver Tissues

Distribution among Species

Aluminum, arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, selenium, silver, tin, and zinc occurred frequently in the liver tissues of all species sampled (**Table 7.2**). Each of these metals was detected in over 90% of the samples. Beryllium, lead, and nickel were also detected, but much less frequently. With the exception of iron and zinc, all concentrations were below 25 ppm.

Several chlorinated pesticides were also detected in liver tissues (**Table 7.3**). Total DDT (the sum of seven metabolites, see Appendix D.2) was found in all samples, with concentrations averaging from 162 ppb in hornyhead turbot to 3439 ppb in California scorpionfish. Other pesticides included chlordane, hexachlorobenzene (HCB), and mirex. Of these, HCB was the most common, occurring in 37% of the samples with values less than 5 ppb. Detected components of chlordane included alpha(*cis*)chlordane, *cis*-nonachlor, and *trans*-nonachlor, each with concentrations less than 30 ppb.

PCBs occurred in all samples from each species of fish. Concentrations for the individual PCB congeners are listed separately in Appendix D.3. Total PCB concentrations (i.e., the sum of all congeners detected in a sample) were variable, ranging from about 3 ppb in a hornyhead turbot sample to 1175 ppb in a California scorpionfish sample. The only detected PAH, 2,6-dimethylnaphthalene, occurred in two hornyhead turbot samples at concentrations around 100 ppb.

Distribution among Stations

Concentrations of the frequently detected metals in fish liver tissues were fairly even across all stations (**Figure 7.2**). Most contaminant concentrations were close to or below the maximum levels detected in the same species prior to discharge. Intraspecific comparisons between the two stations closest to the discharge (SD17, SD18) and those located farther away (SD15–SD16, SD19–SD21) suggest that there was no clear relationship between contaminant loads and proximity to the outfall.

As with metals, there was no clear relationship between concentrations of the frequently occurring pesticides (i.e., DDT, HCB, trans nonachlor) and PCBs and proximity to the outfall (**Figure 7.3**). Most values were below the maximum concentrations detected in the same species prior to discharge. The two notable exceptions were found in two scorpionfish samples collected at SD16 and SD20. Each sample had a substantial amount of DDT in spite of the typically low levels in sediments surrounding the SBOO (see Chapter 4). California scorpionfish are known to travel over vast areas (Hartmann 1987, Love et al. 1987), and these high DDT levels were most likely due to exposure from another area with higher levels of sediment contamination.

Contaminants in Muscle Tissues

To address human health concerns, concentrations of the constituents found in muscle tissue samples were compared to national and international limits and standards (**Table 7.4**). The United States Food and Drug Administration (FDA) has set mercury and total DDT limits for seafood that is to be sold for human consumption (Mearns et al.

Table 7.2

Metals detected in liver tissues from fishes collected at SBOO trawl stations during 2004. Values are expressed as parts per million (ppm); n=number of detected values, nd=not detected.

	Al	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
Hornyhead turbot																
n (out of 16)	16	16	16	4	16	16	16	16	nd	16	16	2	16	15	16	16
Min	0.9	0.9	0.01	0.02	2.2	0.10	2.5	21.7	—	0.73	0.06	0.11	0.42	0.08	0.27	37.1
Max	8.7	8.5	0.07	0.02	9.7	0.47	13.2	74.6	—	1.45	0.29	0.13	1.05	0.49	0.92	60.1
Mean	4.4	2.5	0.03	0.02	5.1	0.23	5.7	39.0	—	1.06	0.12	0.12	0.65	0.22	0.53	50.1
California scorpionfish																
n (out of 9)	9	9	9	3	9	8	9	9	1	9	9	1	9	9	9	9
Min	3.8	0.4	0.04	0.03	1.3	0.15	9.0	72.8	0.39	0.31	0.05	0.10	0.69	0.22	0.42	33.8
Max	16.1	15.8	0.06	0.03	5.9	0.69	23.5	241.0	0.39	2.09	0.44	0.10	1.20	0.72	1.57	104.0
Mean	8.0	3.3	0.04	0.03	3.1	0.32	17.1	167.0	0.39	0.87	0.18	0.10	0.86	0.36	0.87	74.8
Longfin sanddab																
n (out of 8)	8	8	8	6	8	7	8	8	2	8	8	1	8	8	8	8
Min	4.8	0.4	0.02	0.02	1.9	0.10	3.6	69.9	0.31	0.16	0.04	0.10	0.63	0.08	0.34	20.0
Max	10.7	19.8	0.09	0.03	5.2	0.35	14.7	235.0	0.54	1.80	0.21	0.10	1.95	0.38	1.14	53.6
Mean	9.0	8.4	0.04	0.02	3.5	0.19	8.9	157.6	0.42	1.28	0.13	0.10	1.26	0.24	0.86	30.2
Pacific sanddab																
n (out of 1)	1	1	1	1	1	nd	1	1	nd	1	1	nd	1	1	1	1
Min	9.5	0.7	0.02	0.02	1.1	—	11.9	95.6	—	0.36	0.08	—	0.82	0.33	0.96	94.2
Max	9.5	0.7	0.02	0.02	1.1	—	11.9	95.6	—	0.36	0.08	—	0.82	0.33	0.96	94.2
Mean	9.5	0.7	0.02	0.02	1.1	—	11.9	95.6	—	0.36	0.08	—	0.82	0.33	0.96	94.2
ALL SPECIES																
% Detected	100	100	100	41	100	91	100	100	9	100	100	12	100	97	100	100

Table 7.3

Chlorinated pesticides, total PCB, total PAH, and lipids detected in liver tissues from fishes collected at SBOO trawl stations during 2004. A(C)C=Alpha(*cis*)Chlordane, CN=*cis*-nonachlor, TN=*trans*-nonachlor, and HCB=hexachlorobenzene. Values are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt), n=number of detected values, nd=not detected.

	Chlorinated Pesticides						Total	Total	
	DDT	HCB	Mirex	A(C)C	CN	TN	PCB	PAH	Lipids
Hornyhead turbot									
n (out of 16)	16	5	nd	nd	nd	nd	16	2	16
Min	51.0	0.8	—	—	—	—	3.4	104.0	4.5
Max	326.0	1.3	—	—	—	—	132.8	113.0	16.4
Mean	162.0	1.1	—	—	—	—	46.6	108.5	10.6
California scorpionfish									
n (out of 9)	9	5	nd	4	2	8	9	nd	9
Min	193.7	1.1	—	2.9	5.8	3.8	77.6	—	6.4
Max	14808.5	2.8	—	10.0	9.6	27.0	1175.1	—	24.9
Mean	3439.1	1.9	—	6.1	7.7	11.5	459.6	—	19.0
Longfin sanddab									
n (out of 8)	9	3	1	1	1	2	9	nd	9
Min	244.5	1.3	3.4	5.3	6.3	10.0	150.1	—	7.5
Max	1170.8	4.4	3.4	5.3	6.3	11.0	664.5	—	43.1
Mean	648.6	2.6	3.4	5.3	6.3	10.5	319.7	—	17.5
Pacific sanddab									
n (out of 1)	1	nd	nd	nd	nd	1	1	nd	1
Min	531.7	—	—	—	—	6.4	225.6	—	11.4
Max	531.7	—	—	—	—	6.4	225.6	—	11.4
Mean	531.7	—	—	—	—	6.4	225.6	—	11.4
ALL SPECIES									
% Detected	100	37	3	14	9	31	100	6	100

1991). In addition, there are international standards for acceptable concentrations of various metals (Mearns et al. 1991). While many compounds were detected in the muscle tissues of fish collected as part of the SBOO monitoring program, only arsenic and selenium had concentrations that were higher than international standards.

In addition to addressing health concerns, spatial patterns were assessed for total DDT and total PCB, as well as all metals that occurred frequently in fish muscle tissue samples (**Figure 7.4**). Concentrations of these parameters were variable in the tissues of fishes collected at both rig fishing stations, and no clear relationship with proximity to the outfall was evident. Contaminants, including those that exceeded international standards, had similar values at both the nearfield station (RF3) and the farfield station (RF4). Further, most California scorpionfish samples had values close to or below the maximum concentrations detected in the same species prior to discharge.

SUMMARY and CONCLUSIONS

Demersal fish collected around the South Bay Ocean Outfall in 2004 were characterized by contaminant values within the range of those

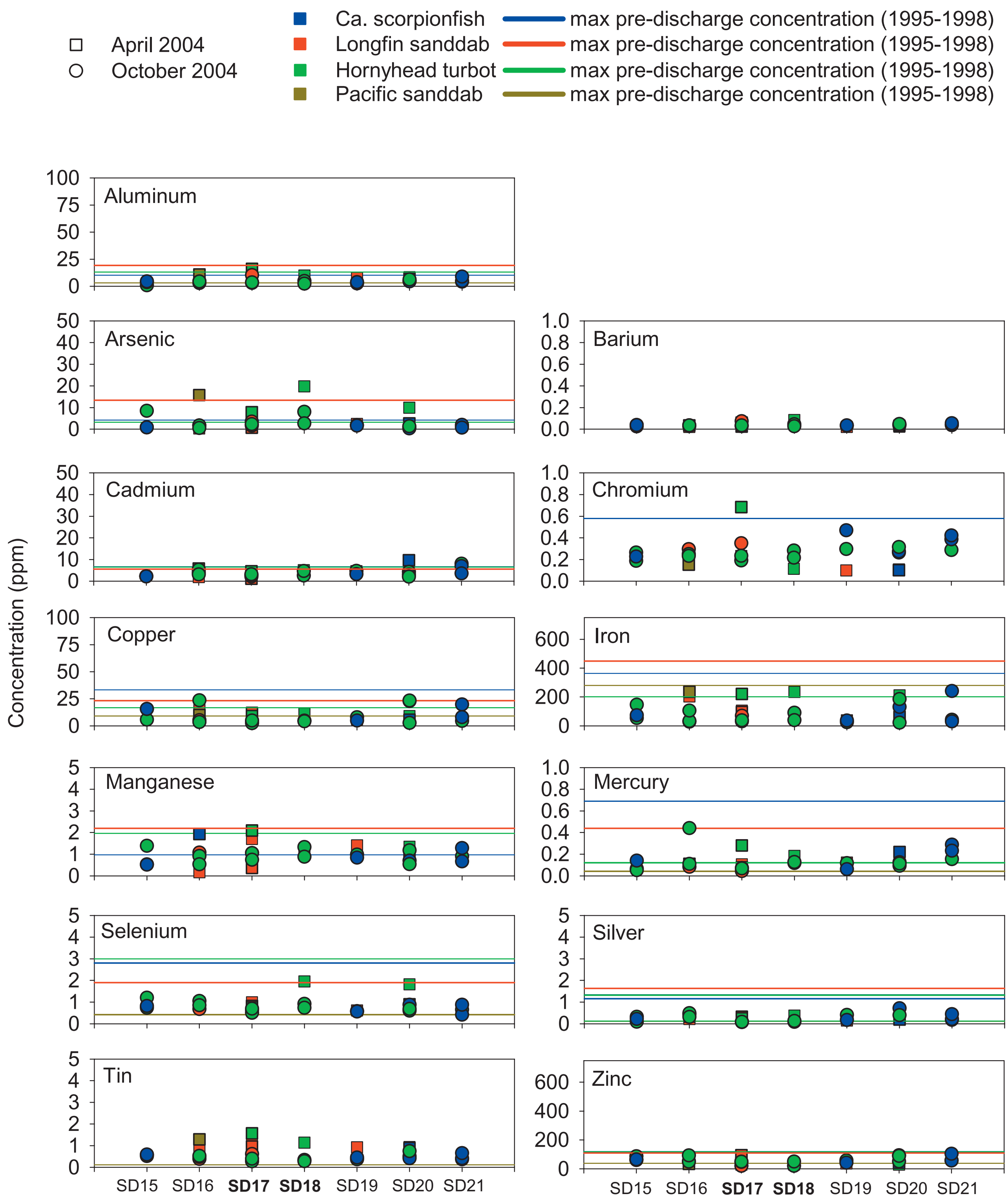

Figure 7.2

Concentrations of frequently detected metals in liver tissues of fishes collected from each SBOO trawl station during 2004. Only three samples were collected at station SD15, five samples at SD16, and three samples at SD19; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995–1998). Stations closest to the discharge site are labeled in bold.

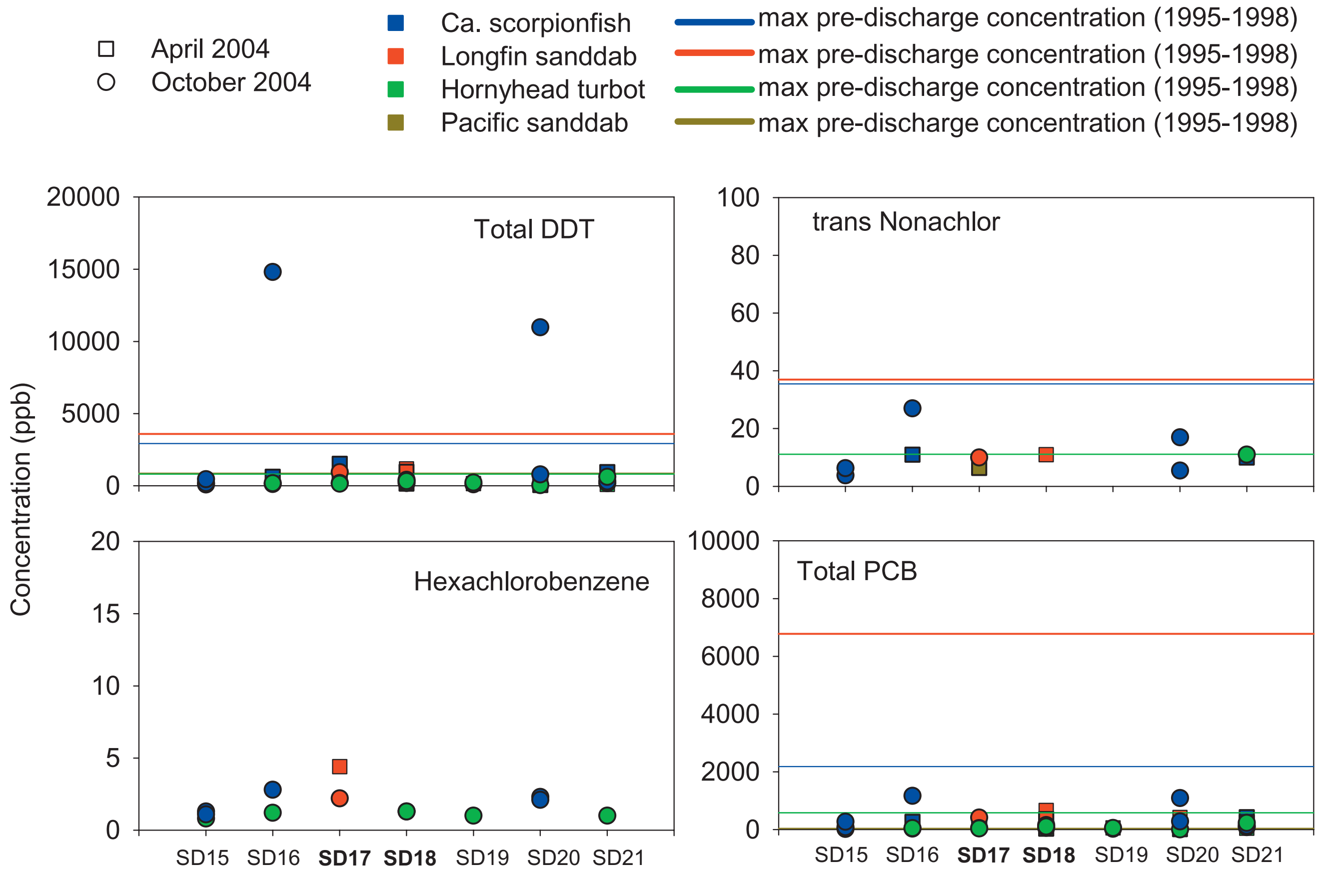

Figure 7.3
Concentrations of frequently detected chlorinated pesticides (total DDT, trans Nonachlor, hexachlorobenzene) and total PCBs in liver tissues of fishes collected from each SBOO trawl station during 2004. Only three samples were collected at station SD15, five samples at SD16, and three samples at SD19; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995–1998). Stations closest to the discharge site are labeled in bold.

reported previously for the Southern California Bight (SCB) (see Mearns et al. 1991, City of San Diego 1996–2001, Allen et al. 1998). In addition, concentrations of most contaminants were not substantially different from pre-discharge data (City of San Diego 2000b).

The frequent occurrence of metals and chlorinated hydrocarbons in SBOO fish tissues may be due to many factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals occur naturally in the environment, although little information is available on their background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998). The lack of contaminant-free reference areas in the SCB clearly pertains to the South Bay region, as demonstrated by the presence of many contaminants in fish tissues prior to the discharge (City of San Diego 2000b). Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species. For example, exposure to contaminants can vary greatly between species and among individuals of the same species depending on migration habits (Otway 1991). Fish may be exposed to contaminants in one highly contaminated area and then move into an area that is less contaminated. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many point and non-point sources that may contribute to contamination in

Table 7.4

Concentrations of various metals and total DDT detected in muscle tissues from fishes collected at SBOO rig fishing stations during 2004. Values are parts per million (ppm) for all parameters. Data for each species are compared to U.S. FDA action limits and median international standards. Bold values exceed these standards, n=number of detected values, nd=not detected.

	As	Cd	Cr	Cu	Pb	Hg	Se	Tn	Zinc	tDDT
California scorpionfish										
n (out of 6)	6	nd	4	6	nd	6	6	6	6	6
Min	1.27	—	0.09	0.11	—	0.10	0.15	0.35	2.66	0.005
Max	**5.43**	—	0.15	0.50	—	0.22	0.27	0.80	6.55	0.047
Mean	**2.50**	—	0.12	0.23	—	0.16	0.20	0.57	4.32	0.015
Vermilion rockfish										
n (out of 3)	3	nd	1	3	nd	3	3	3	3	3
Min	**1.86**	—	0.17	0.14	—	0.06	0.16	0.30	2.70	0.001
Max	**2.57**	—	0.17	0.40	—	0.07	**0.31**	0.72	4.10	0.009
Mean	**2.18**	—	0.17	0.28	—	0.06	0.22	0.57	3.43	0.005
Brown rockfish										
n (out of 3)	3	nd	3	3	nd	3	3	3	3	3
Min	0.94	—	0.11	0.19	—	0.17	0.16	0.32	3.63	0.003
Max	**1.74**	—	0.18	0.32	—	0.21	**0.32**	0.76	4.66	0.012
Mean	1.23	—	0.14	0.23	—	0.19	0.26	0.51	4.00	0.006
US FDA Action Limit*						1				5
Median International Standard*	1.4	1.0	1.0	20	2.0	0.5	0.3	175	70	5

* From Table 2.3 in Mearns et al. 1991. FDA action limit for total DDT is for fish muscle tissue, FDA mercury action limits and all international standards are for shellfish, but are often applied to fish. All limits apply to the sale of seafood for human consumption.

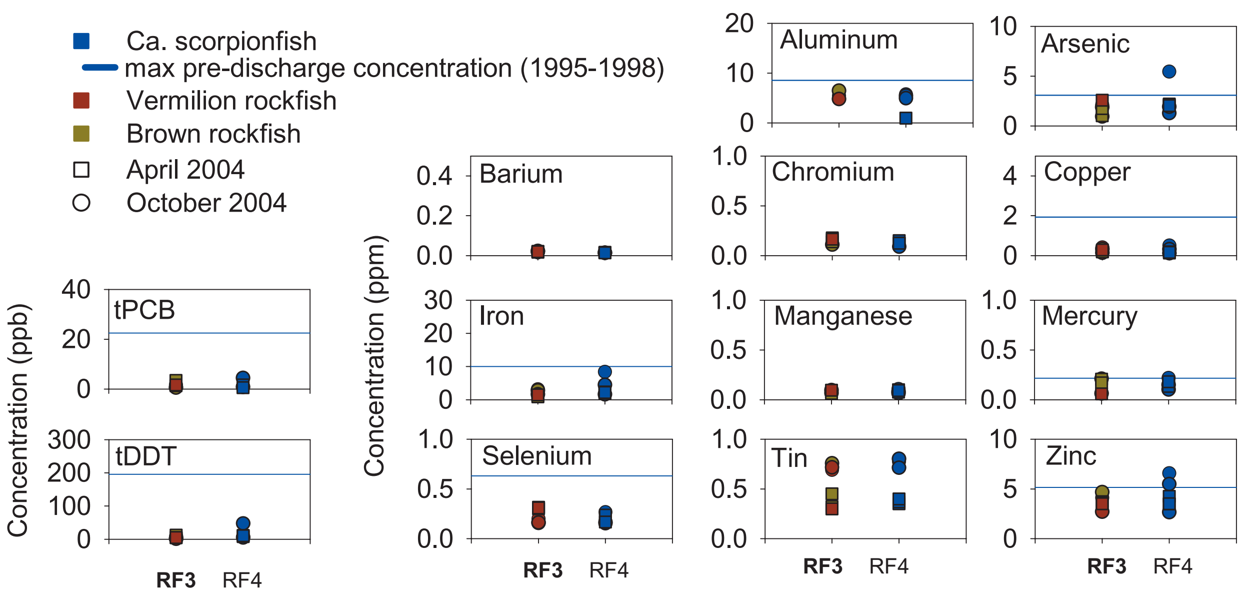

Figure 7.4

Concentrations of frequently detected metals, total DDT and total PCB in muscle tissues of fishes collected from each SBOO rig fishing station during 2004. Missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995-1998) for California scorpionfish. No vermilion or brown rockfish were collected during that period. The station closest to the discharge site is labeled in bold.

the region. For example, some monitoring stations are located near the Tijuana River, San Diego Bay, and dredged materials disposal sites, and input from these sources may affect fish in nearby areas.

Overall, there was no evidence that fishes collected in 2004 were contaminated by the discharge of waste water from the South Bay Ocean Outfall. In addition, concentrations of mercury and DDT in muscle tissues from sport fish collected in the area were below FDA human consumption limits. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot or other physical anomalies (see Chapter 6).

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GLOSSARY

Absorption The movement of a dissolved substance (e.g. pollution) into cells by osmosis or diffusion.

Adsorption The accumulation of a dissolved substance on the sediment or on the surface of an organism (e.g. a flatfish).

Ambicoloration A term specific to flatfish that describes the presence of pigmentation on both the eyed and the blind sides. Normally in flatfish, only the eyed side is pigmented.

Anthropogenic Made and introduced into the environment by humans, especially pertaining to pollutants.

Assemblage An association of interacting populations in a given habitat. For example, an assemblage of benthic invertebrates on the ocean floor.

BACIP(Before-After-Control-Impact-Paired) An analytical tool used to assess environmental changes caused by the effects of pollution. A statistical test is applied to data from matching pairs of control and impacted sites before and after an event (i.e., initiation of wastewater discharge) to test for significant change. Significant differences are generally interpreted as being the result of the environmental change attributed to the event (i.e., initiation of wastewater discharge). Variation that is not significant reflects natural variation.

Benthic Pertaining to the environment inhabited by organisms living on or in the ocean bottom.

Benthos Living organisms (e.g. algae and animals) associated with the sea bottom.

Bioaccumulation The process by which a chemical in animal tissue becomes accumulated over time through direct intake of contaminated water, the consumption of contaminated prey, or absorption through the skin.

BOD (Biochemical Oxygen Demand) The amount of oxygen consumed (through biological or chemical processes) during the decomposition of organic material contained in a water or sediment sample. It is a measure for certain types of organic pollution, such that high BOD levels suggest elevated levels of organic pollution.

Biota The living organisms within a habitat or region.

BRI (Benthic Response Index) An index that measures levels of environmental disturbance by assessing the condition of a benthic assemblage. The index was based on organisms found in the soft sediments of the Southern California Bight.

California Ocean Plan (COP) California's ocean water quality control plan. It limits wastewater discharge and implements ocean monitoring. Federal law requires the plan to be reviewed every three years.

CFU (colony-forming unit) A unit (measurement) of density used to estimate bacteria concentrations in ocean water. The number of bacterial cells that grow to form entire colonies, which can then be quantified visually.

Congeners The EPA defines a congener as, "one of the 209 different PCB compounds. A congener may have between 1 and 10 chlorine atoms, which may be located at various positions on the PCB molecule."

Control site A geographic location that is far enough from a known pollution source (e.g., ocean outfall) to be considered representative of an undisturbed environment. Information collected within control sites is used as a reference and compared to impacted sites.

Crustacea A group (subphylum) of marine invertebrates characterized by jointed legs and an exoskeleton. Crabs, shrimps, and lobsters are examples.

CTD (conductivity, temperature, and depth) A device consisting of a group of sensors that continually measure various physical and chemical properties such as conductivity (a proxy for salinity), temperature, and pressure (a proxy for depth) as it is lowered through the water. These parameters are used to assess the physical ocean environment.

Demersal Organisms living on or near the bottom of the ocean and capable of active swimming. For example, flatfish.

Dendrogram A treelike diagram used to represent hierarchal relationships from a multivariate analysis where results from several monitoring parameters are compared among sites.

Detritus Particles of organic material from decomposing organisms. Used as an important source of nutrients in a food web.

Diversity (Shannon diversity index, H') A measurement of community structure that describes the abundances of different species within a community, taking into account their relative rarity or commonness.

Dominance (Swartz) A measurement of community structure that describes the minimum number of species accounting for 75% of the abundance in each grab.

Echinodermata A group (phylum) of marine invertebrates characterized by the presence of spines, a radially symmetrical body, and tube feet. For example, sea stars, sea urchins, and sea cucumbers

Ectoparasite A parasite that lives on the outside of its host, and not within the host's body. Isopods and leeches attached to flatfish are examples.

Effluent Wastewater that flows out of a sewer, treatment plant outfall, or other point source and is discharged into a water body (e.g. ocean, river).

Epibenthic Referring to organisms that live on or near, not within, the sediments. See demersal.

Epifauna Animals living on the surface of sea bottom sediments.

Halocline A vertical zone of water in which the salinity changes rapidly with depth.

Impact site A geographic location that has been altered by the effects of a pollution source, such as a wastewater outfall.

Indicator Species Marine invertebrates whose presence in the community reflects the health of the environment. The loss of pollution-sensitive species or the introduction of pollution-tolerant species can indicate anthropogenic impact.

Infauna Animals living in the soft bottom sediments usually burrowing or building tubes within.

Invertebrate An animal without a backbone. For example, a seastar, crab, or worm.

ITI (Infaunal Trophic Index) An environmental disturbance index based on the feeding structure of marine soft-bottom benthic communities and the rationale that a change in sediment quality will restructure the invertebrate community to one best suited to feed in the altered sediment type. Generally, ITI values less than 60 indicate a pollution impacted benthic community.

Kurtosis A measure that describes the shape (i.e., peakedness or flatness) of distribution relative to a normal distribution (bell shape) curve. Kurtosis can indicate the range of a data set, and is used herein to describe the distribution of particle sizes within sediment samples.

Macrobenthic invertebrate (Macrofauna) Epifaunal or infaunal benthic invertebrates that are visible with the naked eye. Larger than meiofauna and smaller than megafauna, this group typically includes those animals collected in grab samples from soft-bottom marine habitats and retained on a 1 mm mesh screen.

MDL (method detection limit) The EPA defines MDL as "the minimum concentration that can be determined with 99% confidence that the true concentration is greater than zero."

Megabenthic invertebrate (Megafauna) A larger, usually epibenthic and motile, bottom-dwelling animal such as a sea urchin, crab, or snail. Typically collected by otter trawls with a minimum mesh size of 1 cm.

Mollusca A taxonomic group (phylum) of invertebrates characterized as having a muscular foot, visceral mass, and a shell. Examples include snails, clams, and octupuses.

Motile Self-propelled or actively moving.

NPDES (National Pollutant Discharge Elimination System) A federal permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

Niskin Bottle A long plastic tube with caps open at both ends allowing water to pass through until the caps are triggered to close from the surface. They often are arrayed with several others in a rosette sampler to collect water at various depths.

Non-point source Pollution sources from numerous points, not a specific outlet, generally carried into the ocean by storm water runoff.

Ophiuroidea A taxonomic group (class) of echinoderms that comprises the brittle stars. Brittle stars usually have five long, flexible arms and a central disk-shaped body.

PAHs (Polynuclear aromatic hydrocarbons) The USGS defines PAHs as, "hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases. They are also called Polycyclic Aromatic Hydrocarbons."

PCBs (Polychlorinated biphenyls) The EPA defines PCBs as, "a category, or family, of chemical compounds formed by the addition of Chlorine (C_{l2}) to Biphenyl ($C_{12}H_{10}$), which is a dual-ring structure comprising two 6-carbon Benzene rings linked by a single carbon-carbon bond."

Phi (size) The conventional unit of sediment size based on the log of sediment grain diameter. The larger the Phi number, the smaller the grain size.

Plankton Animal and plant-like organisms, usually microscopic, that are passively carried by the ocean currents.

PLOO (Point Loma Ocean Outfall) The PLOO is the underwater pipe originating at the Point Loma Wastewater Treatment Plant and used to discharge treated wastewater. It extends 7.2 km (4.5 miles) offshore and discharges into about 96 m (320 ft) of water.

Point source Pollution discharged from a single source (e.g. municipal wastewater treatment plant, storm drain) to a specific location through a pipe or outfall.

Polychaeta A taxonomic group (class) of invertebrates characterized as having worm-like features, segments, and bristles or tiny hairs. Examples include bristle worms

Pycnocline A depth zone in the ocean where density increases (associated with a decline in temperature and increase in salinity) rapidly with depth.

Recruitment In an open ocean environment, the retention of young individuals into the adult population.

Red relict sand Coarse reddish-brown sand that is a remnant of a pre-existing formation after other parts have disappeared. Typically originating from land and transported to the ocean bottom through erosional processes.

Rosette sampler
A device consisting of a round metal frame housing a CTD in the center and multiple bottles (see Niskin bottle) arrayed about the perimeter. As the instrument is lowered through the water column, continuous measurements of various physical and chemical parameters are recorded by the CTD, and discrete water samples can be captured at desired depths by the bottles.

Shell hash Sediment composed of shell fragments with the size and consistency of very coarse sand.

Skewness A measure of the lack of symmetry in a distribution or data set. Skewness can indicate where within a distribution most of the data lies. It is used herein to describe the distribution of particle sizes within sediment grain size samples.

Sorting The range of grain sizes comprising marine sediments, and may also refer to the process by which sediments of similar size are naturally segregated during transport and deposition according to the velocity and transporting medium. Well-sorted sediments are of similar size (such as desert sand), while poorly-sorted sediments have a wide range of grain sizes (as in a glacial till).

SBOO (South Bay Ocean Outfall) The SBOO is the underwater pipe originating at the International Wastewater Treatment Plant and used to discharge treated wastewater. It extends 5.6 km (4.5 miles) offshore and discharges into about 27 m (90 ft) of water.

South Bay Water Reclamation Plant Provides local wastewater treatment services and reclaimed water to the South Bay. The plant began operation in 2002 and has a wastewater treatment capacity of 15 million gallons a day

SCB (Southern California Bight) The geographic region that stretches from Point Conception, U.S.A. to the Cabo Colnett, Mexico, and encompasses nearly 80,000 km^2 of coastal land and sea

Species Richness The number of species per unit area. A metric used to evaluate the health of macrobenthic communities.

Standard length The measurement of a fish from the most forward tip of the body to the base of the tail but excluding the tail fin rays. Fin rays can sometimes be eroded by pollution or preservation so a measurement that includes them (i.e., total length) is considered less reliable.

Terrigenous Referring to suspended oceanic sediments derived from land-based material.

Thermocline The zone in a thermally stratified body of water that separates warmer surface water from colder deep water. At a thermocline, temperature decreases rapidly over a short depth.

Tissue burden Refers to the total amount of measured chemicals that are present in the tissue (e.g. fish muscle) at a given point in time.

Transmissivity A measure of water clarity based upon the ability of water to transmit light along a straight path. Light that is scattered or absorbed by particulates (e.g., plankton, suspended solid materials) decreases the transmissivity (or clarity) of the water.

Upwelling The movement of nutrient-rich, and typically cold, water from the depths of the ocean to the surface waters.

USGS (United States Geological Survey) The USGS provides geologic, topographic, and hydrologic information on water, biological, energy, and mineral resources.

Van Dorn bottle A water-sampling device made of a plastic tube open at both ends that allows water to flow through. Rubber caps at the tube ends can be triggered to close underwater to collect water at a specified depth.

Van Veen Grab A mechanical device designed to collect bottom sediment samples. The device consists of a pair of hinged jaws and a release mechanism that allows the opened jaws to close and entrap a 0.1 m^2 sediment sample once they touch bottom.

Wastewater A mixture of water and waste materials originating from homes, businesses, and industries.

ZID (zone of initial dilution) The region of initial mixing of the surrounding receiving waters with wastewater from the diffuser ports of the outfall. This area includes the underlying seabed. In the ZID, the environment is chronically exposed to pollutants and often is the most impacted.

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Appendix A

Supporting Data

2004 SBOO Stations

Microbiology

Appendix A.1

Bacteriological samples with total coliform densities ≥1000 CFU/100 mL and fecal to total coliform ratio (F:T) ≥0.1 collected from SBOO offshore stations during 2004. Total coliform (Total), fecal coliform (Fecal), and enterococcus bacteriological densities are expressed as CFU/100 mL. Depth in meters

	Site	Date	Sample depth	Total	Fecal	Enterococcus	Ratio (F:T)
Inshore							
	I39	Mar	2	1700	240	24	0.14
	I39		18	1800	200	16	0.11
	I18	Apr	18	1200	240	10	0.20
	I25		9	16000	4800	260	0.30
	I25		6	16000	3400	200	0.21
	I18	Sep	12	16000	8600	820	0.54
	I32	Dec	6	16000	3000	2000	0.19
	I32		9	16000	1800	1200	0.11
	I32		2	16000	1600	1000	0.10
North							
	I30	Apr	18	2400	480	14	0.20
	I22	Jun	18	16000	2200	240	0.14
	I30	Sep	27	1400	400	150	0.29
South							
	I03	Apr	18	9200	3600	360	0.39
	I09		27	4200	740	2	0.18
Outfall							
	I12	Jan	2	8200	2800	740	0.34
	I16		27	16000	7200	560	0.45
	I16		18	16000	5800	800	0.36
	I12	Mar	2	16000	12000	4000	0.75
	I16		2	16000	12000	3600	0.75
	I16		18	16000	12000	2400	0.75
	I16		27	16000	2800	240	0.18
	I12	Apr	27	16000	12000	3600	0.75
	I16		27	1300	180	14	0.14
	I16	May	18	12000	4200	380	0.35
	I14	Jun	18	5400	1200	220	0.22
	I16		18	2200	660	68	0.30
	I12	Jul	18	16000	12000	13000	0.75
	I16		18	16000	16000	2400	1.00
	I12	Aug	27	16000	6200	1000	0.39
	I16	Sep	18	16000	2600	1100	0.16
	I12	Nov	18	16000	4600	560	0.29

Appendix A.2

Bacteriological samples with total coliform densities ≥1000 CFU/100 mL and fecal to total coliform ratio (F:T) < 0.1collected from SBOO offshore stations during 2004. Total coliform (Total), fecal coliform (Fecal), and enterococcus bacteriological densities are expressed as CFU/100 mL. Depth in meters.

	Site	Date	Sample depth	Total	Fecal	Enterococcus	Ratio (F:T)
Inshore							
	I19	Jan	11	1200	2	2	0.00
	I24		6	1800	2	2	0.00
	I19	Feb	6	2000	26	6	0.01
	I19	Mar	6	16000	520	280	0.03
	I19		2	16000	420	360	0.03
	I19		11	16000	320	340	0.02
	I24		11	1100	28	18	0.03
	I24		6	1100	14	6	0.01
	I26		9	1000	4	14	0.00
	I39		12	5000	380	18	0.08
	I40		9	16000	320	28	0.02
	I40		2	4000	18	4	0.00
	I40		6	9800	32	2	0.00
	I05		6	3600	220	100	0.06
	I05		11	16000	220	180	0.01
	I05		2	1800	12	18	0.01
	I11		6	16000	140	78	0.01
	I11		2	8200	48	34	0.01
	I19	Apr	6	16000	340	18	0.02
	I19		2	1200	24	2	0.02
	I24		2	16000	480	34	0.03
	I24		6	16000	440	26	0.03
	I24		11	4400	74	20	0.02
	I25		2	4800	100	10	0.02
	I40		2	16000	1200	46	0.08
	I40		9	1100	32	16	0.03
	I40		6	10000	200	20	0.02
	I18	Sep	18	11000	660	60	0.06
	I18	Nov	2	6600	120	46	0.02
	I19		11	1800	140	400	0.08
	I19		2	6600	340	160	0.05
	I19		6	3400	140	460	0.04
	I24		11	1800	160	580	0.09
	I26		9	1600	100	360	0.06
	I32		9	1000	66	380	0.07
	I40		6	16000	880	320	0.06
	I40		9	2400	100	220	0.04
	I40		2	16000	600	320	0.04
	I36	Dec	11	4200	64	36	0.02
	I38		11	1000	26	16	0.03
North							
	I22	Dec	2	1600	38	6	0.02
South							
	I09	Feb	27	4000	140	6	0.04
	I03	Aug	18	3000	260	22	0.09
Outfall							
	I12	Mar	18	1200	110	8	0.09
	I14		18	5200	220	12	0.04
	I16	Oct	2	3400	300	560	0.09
	I14	Dec	2	16000	76	6	0.00
	I14		27	1000	2	6	0.00
	I16		18	16000	52	12	0.00

Appendix B

Supporting Data

2004 SBOO Stations

Sediment Characteristics

Appendix B.1

Sediment chemistry constituents analyzed for South Bay Ocean Outfall sampling during 2004.

Cholorinated Pesticides

Aldrin	BHC, Delta isomer	Endrin Aldehyde	Mirex	p,p-DDE
Alpha (cis) Chlordane	BHC, Gamma isomer	Gamma (trans) Chlordane	o,p-DDD	p,p-DDT
Alpha Endosulfan	Cis_Nonachlor	Heptachlor	o,p-DDE	Trans Nonachlor
Beta Enddosulfan	Dieldrin	Heptachlor epoxide	o,p-DDT	
BHC, Alpha isomer	Endosulfan sulfate	Hexachlorobenzene	Oxychlordane	
BHC, Beta isomer	Endrin	Methoxychlor	p,p-DDD	

Polycylic Aromatic Hydrocarbons

1-methylnaphthalene	Acenaphthene	Benzo[G,H,I]perylene	Fluorene
1-methylphenanthrene	Acenaphthylene	Benzo[K]fluoranthene	Indeno(1,2,3-CD)pyrene
2,3,5-trimethylnaphthalene	Anthracene	Biphenyl	Naphthalene
2,6-dimethylnaphthalene	Benzo[A]anthracene	Chrysene	Perylene
2-methylnaphthalene	Benzo[A]pyrene	Dibenzo(A,H)anthracene	Phenanthrene
3,4-benzo(B)fluoranthene	Benzo[e]pyrene	Fluoranthene	Pyrene

Metals

Aluminum (Al)	Cadmium (Cd)	Manganese (Mn)	Silver (Ag)
Antimony (Sb)	Chromium (Cr)	Mercury (Hg)	Thallium (Tl)
Arsenic (As)	Copper (Cu)	Nickel (Ni)	Tin (Sn)
Barium (Ba)	Iron (Fe)	Selenium (Se)	Zinc (Zn)
Beryllium (Be)	Lead (Pb)		

PCB Congeners

PCB 18	PCB 81	PCB 126	PCB 169
PCB 28	PCB 87	PCB 128	PCB 170
PCB 37	PCB 99	PCB 138	PCB 177
PCB 44	PCB 101	PCB 149	PCB 180
PCB 49	PCB 105	PCB 151	PCB 183
PCB 52	PCB 110	PCB 153/168	PCB 187
PCB 66	PCB 114	PCB 156	PCB 189
PCB 70	PCB 118	PCB 157	PCB 194
PCB 74	PCB 119	PCB 158	PCB 201
PCB 77	PCB 123	PCB 167	PCB 206

Appendix B.2
SBOO sediment statistics January 2004.

Station	Mean Phi	Std Dev. Phi	Median Phi	Mean mm	Skewness	Kurtosis	Coarse %	Sand %	Silt %	Clay %
19-m stations										
I35	3.7	1.2	3.5	0.077	0.3	1.2	0.0	65.0	33.5	1.5
I34	0.3	1.0	0.5	0.795	-0.1	1.3	26.0	73.9	0.0	0.0
I31	3.1	0.7	3.1	0.119	0.1	1.2	0.0	92.6	7.2	0.1
I23	3.1	0.8	3.0	0.115	0.1	6.8	0.9	89.7	9.2	0.2
I18	3.1	0.9	3.1	0.120	-0.0	1.5	0.3	89.8	9.5	0.1
I10	3.0	1.0	3.0	0.124	-0.1	1.5	0.7	89.7	9.3	0.1
I4	1.1	0.9	1.0	0.465	0.2	0.9	7.0	92.8	0.2	0.0
28-m stations										
I33	2.9	1.0	2.8	0.132	0.2	1.8	0.3	90.1	9.2	0.4
I30	3.2	0.9	3.3	0.106	0.0	1.5	0.3	85.6	13.6	0.5
I27	3.2	1.0	3.2	0.109	-0.1	1.7	0.4	86.1	13.0	0.5
I22	3.1	1.2	3.1	0.119	0.1	1.8	0.2	85.7	12.8	0.5
I14	3.2	0.9	3.2	0.110	-0.1	1.5	0.3	86.7	12.6	0.3
I15	3.0	1.2	3.0	0.128	-0.0	1.6	0.2	84.1	15.2	0.5
I16	2.8	0.9	2.8	0.142	0.1	1.4	0.0	92.8	6.8	0.1
I12	2.3	1.1	2.4	0.202	-0.1	1.1	1.9	92.5	5.5	0.0
I9	3.2	1.0	3.3	0.107	-0.0	1.6	0.3	84.8	14.4	0.5
I6	1.4	0.9	1.4	0.366	0.0	0.9	5.3	93.6	1.0	0.0
I2	1.5	0.8	1.5	0.364	-0.1	0.9	4.9	95.1	0.0	0.0
I3	0.5	0.6	0.4	0.697	0.4	1.2	16.1	83.9	0.0	0.0
38-m stations										
I29	1.9	3.3	0.6	0.266	0.8	2.4	23.4	57.3	8.0	6.3
I21	0.8	0.7	0.8	0.572	0.1	1.1	9.5	90.5	0.0	0.0
I13	1.2	0.8	1.1	0.446	0.1	0.9	6.5	93.3	0.2	0.0
I8	1.5	0.9	1.5	0.353	-0.0	0.9	4.9	93.4	1.6	0.0
55-m stations										
I28	2.7	2.5	2.9	0.150	-0.0	0.8	10.0	62.7	25.4	1.9
I20	1.5	0.9	1.6	0.342	-0.1	0.9	5.2	94.1	0.7	0.0
I7	0.8	0.8	0.7	0.568	0.2	1.1	11.5	88.1	0.3	0.0
I1	2.8	1.0	2.7	0.149	0.2	1.9	0.3	91.3	8.0	0.4

Appendix B.2
SBOO sediment statistics July 2004.

Station	Mean Phi	Std Dev. Phi	Median Phi	Mean mm	Skewness	Kurtosis	Coarse %	Sand %	Silt %	Clay %
19-m stations										
I35	3.7	1.2	3.5	0.080	0.2	1.2	0.0	66.3	32.6	1.1
I34	1.6	2.3	1.6	0.335	0.4	3.4	5.5	88.1	0.2	1.2
I31	3.1	0.8	3.1	0.119	0.1	1.4	0.0	91.1	8.7	0.2
I23	3.1	0.9	3.1	0.117	0.1	1.5	0.0	89.0	10.6	0.2
I18	3.2	0.9	3.2	0.110	0.1	1.4	0.0	84.7	14.6	0.3
I10	3.1	0.8	3.1	0.118	0.1	1.3	0.0	90.5	9.2	0.1
I4	1.0	0.8	0.9	0.490	0.2	1.0	7.2	91.6	1.1	0.0
28-m stations										
I33	2.9	1.1	2.8	0.130	0.3	1.9	0.4	88.5	10.2	0.6
I30	3.3	0.8	3.3	0.102	0.2	1.5	0.0	85.2	14.1	0.4
I27	3.2	0.9	3.2	0.110	0.0	1.4	0.0	87.7	12.0	0.4
I22	2.4	1.0	2.5	0.183	0.1	1.3	0.0	92.8	7.1	0.0
I14	3.2	0.8	3.1	0.105	0.4	1.9	0.0	85.7	13.8	0.5
I15	2.8	1.4	2.8	0.143	0.2	1.6	0.0	85.7	11.7	0.4
I16	2.3	0.9	2.4	0.201	-0.1	1.2	0.3	94.7	4.8	0.0
I12	1.5	1.0	1.6	0.345	-0.0	0.9	4.8	94.0	1.2	0.0
I9	3.3	1.0	3.3	0.103	-0.0	1.7	0.3	83.7	15.4	0.5
I6	1.6	1.8	1.1	0.342	0.5	1.0	8.3	79.3	11.9	0.4
I2	1.6	0.8	1.6	0.326	-0.0	0.9	4.4	95.1	0.5	0.0
I3	1.4	0.9	1.5	0.367	-0.0	1.0	4.9	93.0	0.0	0.0
38-m stations										
I29	3.5	1.1	3.5	0.087	0.2	1.5	0.0	72.7	26.3	1.1
I21	1.1	0.8	1.0	0.481	0.1	0.7	6.9	91.1	2.0	0.0
I13	1.0	1.3	0.9	0.486	0.5	1.9	8.3	85.7	2.7	0.0
I8	1.0	0.8	0.9	0.499	0.2	1.0	8.4	90.4	1.2	0.0
55-m stations										
I28	2.3	1.7	2.3	0.208	-0.1	0.7	11.4	61.9	26.6	0.0
I20	0.8	2.3	0.6	0.568	0.6	5.2	18.7	70.0	1.1	5.1
I7	0.7	0.6	0.6	0.637	0.2	1.1	13.6	86.3	0.0	0.0
I1	2.8	1.1	2.8	0.149	0.0	3.1	0.9	91.3	7.6	0.2

Appendix B.2

Mean concentraions of total PAH and pesticides found at each SBOO station during 2004.

Station	Total PAH ppt	Total DDT ppt	p,p-DDE ppt
19-m stations			
I35	139	nd	nd
I34	88	nd	nd
I31	111	nd	nd
I23	71	nd	nd
I18	136	nd	nd
I10	208	nd	nd
I4	116	nd	nd
28-m stations			
I33	341	nd	nd
I30	176	nd	nd
I27	522	nd	nd
I22	178	nd	nd
I14	139	nd	nd
I15	138	240	240
I16	119	nd	nd
I12	143	nd	nd
I9	169	nd	nd
I6	132	nd	nd
I2	115	nd	nd
I3	163	nd	nd
38-m stations			
I29	116	825	825
I21	108	nd	nd
I13	112	nd	nd
I8	155	nd	nd
55-m stations			
I28	120	350	350
I20	152	nd	nd
I7	136	nd	nd
I1	174	nd	nd

Appendix C

Supporting Data

2004 SBOO Stations

Demersal Fishes and Megabenthic Invertebrates

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Appendix C.1

Summary of demersal fish species captured during 2004 at SBOO stations. Data are number of fish collected (N) and minimum, maximum and mean length (cm SL).

			LENGTH		
Taxon/Species	**Common Name**	**N**	**Min**	**Max**	**Mean**
RAJIFORMES					
Rhinobatidae					
Platyrhinoidis triseriata	thornback	1	54	54	54
Rhinobatos productus	shovelnose guitarfish	1	52	52	52
Rajidae					
Raja inornata	California skate	6	33	55	43
CLUPEIFORMES					
Engraulidae					
Engraulis mordax	northern anchovy	4	9	10	10
AULOPIFORMES					
Synodontidae					
Synodus lucioceps	California lizardfish	184	7	26	13
OPHIDIIFORMES					
Ophidiidae					
Chilara taylori	spotted cusk-eel	1	6	6	6
BATRACHOIDIFORMES					
Batrachoididae					
Porichthys myriaster	specklefin midshipman	1	29	29	29
Porichthys notatus	plainfin midshipman	25	3	15	9
GASTEROSTEIFORMES					
Syngnathidae					
Syngnathus californiensis	kelp pipefish	1	14	14	14
SCORPAENIFORMES					
Sebastidae					
Sebastes dallii	calico rockfish	1	7	7	7
Scorpaenidae					
Scorpaena guttata	California scorpionfish	20	13	24	20
Hexagrammidae					
Zaniolepis latipinnis	longspine combfish	17	13	15	14
Cottidae					
Chitonotus pugetensis	roughback sculpin	258	4	12	7
Icelinus quadriseriatus	yellowchin sculpin	141	3	8	6
Agonidae					
Odontopyxis trispinosa	pygmy poacher	6	5	8	6
PERCIFORMES					
Carangidae					
Trachurus symmetricus	Pacific jack mackerel	1	18	18	18

Appendix C.1 continued

Taxon/Species	Common Name	N	LENGTH Min	Max	Mean
Sciaenidae					
Genyonemus lineatus	white croaker	4	15	21	18
Embiotocidae					
Cymatogaster aggregata	shiner perch	4	9	10	9
PLEURONECTIFORMES					
Paralichthyidae					
Citharichthys sordidus	Pacific sanddab	11	11	20	14
Citharichthys stigmaeus	speckled sanddab	5019	3	13	8
Citharichthys xanthostigma	longfin sanddab	38	11	18	15
Hippoglossina stomata	bigmouth sole	3	16	18	17
Paralichthys californicus	California halibut	13	26	79	36
Xystreurys liolepis	fantail sole	5	5	33	16
Pleuronectidae					
Hypsopsetta guttulata	diamond turbot	2	21	23	22
Pleuronectes vetulus	English sole	33	8	25	15
Pleuronichthys decurrens	curlfin sole	2	12	14	13
Pleuronichthys ritteri	spotted turbot	21	12	21	16
Pleuronichthys verticalis	hornyhead turbot	172	3	23	11
Cynoglossidae					
Symphurus atricauda	California tonguefish	15	7	16	11

Taxonomic arrangement and scientific names are of Eschmeyer (1998) and update of this on California academy of Sciences website (as of 27 May, 2003).

Appendix C.2

Summary of megabenthic invertebrate taxa captured during 2003 at SBOO stations. Data are number of individuals collected (N).

TAXON/SPECIES	N
PLATYHEMINTHES	
TURBELLARIA	
POLYCLADIA	2
MOLLUSCA	
GASTROPODA	
VETIGASTROPODA	
Turbinidae	
Megastraea undosa	2
Calliostomatidae	
Calliostoma canaliculatum	1
NEOTAENIOGLOSSA	
Naticidae	
Euspira lewisii	3
Bursidae	
Crossata californica	10
NEOGASTROPODA	
Muricidae	
Pteropurpura festiva	1
Buccinidae	
Kelletia kelletii	22
Turridae	
Crassispira semiinflata	3
CEPHALASPIDEA	
Philinidae	
Philine auriformis	212
NUDIBRANCHIA	
Onchidorididae	
Acanthodoris brunnea	2
Acanthodoris rhodoceras	1
Dendronotidae	
Dendronotus diversicolor	1
Dendronotus frondosus	3
Dendronotus iris	1
Flabellinidae	
Flabellina iodinea	4
Flabellina pricei	1
Facelinidae	
Hermissenda crassicornis	1

Appendix C.2 continued

Taxon/ Species	N
BIVALVIA	
MYTILOIDA	
Mytilidae	
Modiolus neglectus	1
OSTREOIDA	
PECTINIDAE	2
CEPHALOPODA	
OCTOPODA	
Octopodidae	
Octopus rubescens	4
Octopus sp	1
ANNELIDA	
POLYCHATEA	
PHYLLODOCIDA	
Aphroditidae	
Aphrodita refulgida	1
ARTHROPODA	
MALACOSTRACA	
STOMATOPODA	
Hemisquillidae	
Hemisquilla ensigera californiensis	9
ISOPODA	
Cymothoidae	
Elthusa vulgaris	10
Elthusa sp	2
DECAPODA	
Sicyoniidae	
Sicyonia ingentis	5
Pandalidae	
Pandalus platyceros	1
Hippolytidae	
Heptacarpus palpator	20
Heptacarpus stimpsoni	17
Spirontocaris prionota	3
Crangonidae	
Crangon alaskensis	6
Crangon alba	4
Crangon nigromaculata	86
Diogenidae	
Paguristes bakeri	1
Paguridae	
Pagurus spilocarpus	9
Pagurus sp	1
Porcellanidae	
Pachycheles pubescens	3
Calappidae	
Platymera gaudichaudii	2
Leucosiidae	
Randallia ornata	4

Appendix C.2 continued

Taxon/ Species	N
Majidae	
Erileptus spinosus	1
Loxorhynchus grandis	6
Loxorhynchus sp	3
Podochela hemphillii	5
Pugettia producta	1
Pyromaia tuberculata	45
Parthenopidae	
Heterocrypta occidentalis	19
Cancridae	
Cancer antennarius	1
Cancer anthonyi	3
Cancer gracilis	43
Cancer jordani	1
Cancer sp	3
Portunidae	
Portunus xantusii	5
Xanthidae	
Lophopanopeus bellus	1
Paraxanthias taylori	1
Grapsidae	
ECHINODERMATA	
ASTEROIDEA	
PAXILLOSIDA	
Astropectinidae	
Astropecten verrilli	665
VALVATIDA	
Asterinidae	
Asterina miniata	2
FORCIPULATIDA	
Asteriidae	
Pisaster brevispinus	25
Pycnopodia helianthoides	1
OPHIUROIDEA	
OPHIURIDA	
Ophiotricidae	
Ophiothrix spiculata	37
ECHINOIDEA	
TEMNOPLEUROIDA	
Toxopneustidae	
Lytechinus pictus	158
ECHINOIDA	
Strongylocentrotidae	
Strongylocentrotus purpuratus	1
CLYPEASTEROIDA	
Dendrasteridae	
Dendraster terminalis	130

Taxonomic arrangement from SCAMIT listing 4th edition 2001.

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Appendix D

Supporting Data

2004 SBOO Stations

Bioaccumulation of Contaminants in Fish Tissue

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Appendix D. 1

Lengths (cm) and weights (g) of fishes used in composite samples for April and October 2004.

Station	Rep	Species	N	min lnth	max lnth	avg lnth	min wt	max wt	avg wt
April 2004									
RF3	1	Vermilion rockfish	3	27	28	28	607	700	639
RF3	2	Brown rockfish	3	23	27	25	397	514	437
RF3	3	Vermilion rockfish	3	23	25	24	348	430	396
RF4	1	California scorpionfish	3	23	27	25	453	650	536
RF4	2	California scorpionfish	3	27	28	27	583	750	642
RF4	3	California scorpionfish	3	22	26	24	395	583	470
SD15	1	(no sample)							
SD15	2	(no sample)							
SD15	3	(no sample)							
SD16	1	Longfin sanddab	8	15	20	16	58	149	89
SD16	2	California scorpionfish	3	21	26	24	351	597	485
SD16	3	(no sample)							
SD17	1	Longfin sanddab	7	16	19	17	80	157	97
SD17	2	Pacific sanddab	10	13	16	15	35	68	49
SD17	3	California scorpionfish	3	22	24	23	425	572	491
SD18	1	Longfin sanddab	8	14	18	16	50	119	85
SD18	2	Longfin sanddab	6	15	20	17	57	166	103
SD18	3	Hornyhead turbot	5	17	22	19	138	293	217
SD19	1	Hornyhead turbot	6	14	19	16	66	177	118
SD19	2	(no sample)							
SD19	3	(no sample)							
SD20	1	Longfin sanddab	6	14	17	16	55	124	93
SD20	2	Hornyhead turbot	6	14	20	17	67	259	138
SD20	3	Longfin sanddab	6	13	15	14	42	60	51
SD21	1	Hornyhead turbot	4	17	22	20	143	323	254
SD21	2	California scorpionfish	3	23	25	24	55	560	318
SD21	3	Longfin sanddab	8	14	18	16	54	123	78
October 2004									
RF3	1	Brown rockfish	3	24	25	25	450	500	483
RF3	2	Brown rockfish	3	22	27	24	288	581	406
RF3	3	Vermilion rockfish	3	27	31	30	700	1000	867
RF4	1	California scorpionfish	3	23	24	23	450	550	500
RF4	2	California scorpionfish	3	22	26	24	500	600	533
RF4	3	California scorpionfish	3	16	29	22	200	900	500
SD15	1	Hornyhead turbot	6	15	18	16	83	169	122
SD15	2	California scorpionfish	3	18	21	19	205	289	247
SD15	3	California scorpionfish	3	14	22	18	87	425	228
SD16	1	Hornyhead turbot	6	15	21	17	90	253	124
SD16	2	Hornyhead turbot	5	16	20	18	109	182	151
SD16	3	California scorpionfish	3	19	25	22	213	473	327
SD17	1	Longfin sanddab	5	13	17	16	41	106	82
SD17	2	Hornyhead turbot	7	15	18	16	94	160	124
SD17	3	Hornyhead turbot	6	15	21	17	85	264	126
SD18	1	Longfin sanddab	3	15	21	19	64	222	161
SD18	2	Hornyhead turbot	5	17	21	18	126	258	158
SD18	3	Hornyhead turbot	5	16	20	18	133	217	156
SD19	1	Hornyhead turbot	4	17	22	19	120	285	190
SD19	2	Hornyhead turbot	8	14	17	15	70	130	94
SD19	3	(no sample)							
SD20	1	Hornyhead turbot	3	16	22	19	115	313	222
SD20	2	California scorpionfish	3	16	20	18	122	269	198
SD20	3	California scorpionfish	3	13	21	18	79	305	207
SD21	1	Hornyhead turbot	6	15	20	16	88	242	125
SD21	2	California scorpionfish	3	17	21	20	141	250	210
SD21	3	Hornyhead turbot	3	20	22	21	253	366	317

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Appendix D.2

Analyzed constituents for fish tissue samples for April and October 2004.

Chlorinated Pesticides

Aldrin	BHC, Gamma isomer	Hexachlorobenzene	p,p-DDE
Alpha (cis) Chlordane	Cis Nonachlor	Mirex	p,p-DDMU
Gamma (trans) Chlordane	Dieldrin	o,p-DDD	p,p-DDT
Alpha Endosulfan	Endrin	o,p-DDE	Oxychlordane
BHC, Alpha isomer	Heptachlor	o,p-DDT	Trans Nonachlor
BHC, Beta isomer	Heptachlor epoxide	p,p-DDD	Toxaphene
BHC, Delta isomer			

Polycyclic Aromatic Hydrocarbons

1-methylnaphthalene	Acenaphthene	Benzo(e)pyrene	Fluorene
1-methylphenanthrene	Acenaphthylene	Benzo(G,H,I)perylene	Indeno(1,2,3-CD)pyrene
2,3,5-trimethylnaphthalene	Anthracene	Benzo(K)fluoranthene	Naphthalene
2,6-dimethylnaphthalene	Benzo(A)anthracene	Biphenyl	Perylene
2-methylnaphthalene	Dibenzo(A,H)anthracene	Chrysene	Phenanthrene
3,4-benzo(B)fluoranthene	Benzo(A)pyrene	Fluoranthene	Pyrene

Metals

Aluminum	Cadmium	Manganese	Silver
Antimony	Chromium	Mercury	Thallium
Arsenic	Copper	Nickel	Tin
Barium	Iron	Selenium	Zinc
Beryllium	Lead		

PCB Congeners

PCB 18	PCB 81	PCB 126	PCB 169
PCB 28	PCB 87	PCB 128	PCB 170
PCB 37	PCB 99	PCB 138	PCB 177
PCB 44	PCB 101	PCB 149	PCB 180
PCB 49	PCB 105	PCB 151	PCB 183
PCB 52	PCB 110	PCB 153/168	PCB 187
PCB 66	PCB 114	PCB 156	PCB 189
PCB 70	PCB 118	PCB 157	PCB 194
PCB 74	PCB 119	PCB 158	PCB 201
PCB 77	PCB 123	PCB 167	PCB 206

Appendix D.3
April 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF3	1	Vermilion rockfish	Muscle	Aluminum		5.38	mg/kg	0.583
RF3	1	Vermilion rockfish	Muscle	Arsenic		2.1	mg/kg	0.375
RF3	1	Vermilion rockfish	Muscle	Barium		0.015	mg/kg	0.007
RF3	1	Vermilion rockfish	Muscle	Beryllium		0.015	mg/kg	0.003
RF3	1	Vermilion rockfish	Muscle	Copper		0.4	mg/kg	0.068
RF3	1	Vermilion rockfish	Muscle	Iron		3.1	mg/kg	0.096
RF3	1	Vermilion rockfish	Muscle	Lipids		1.17	wt%	0.005
RF3	1	Vermilion rockfish	Muscle	Manganese		0.09	mg/kg	0.007
RF3	1	Vermilion rockfish	Muscle	Mercury		0.067	mg/kg	0.03
RF3	1	Vermilion rockfish	Muscle	p,p-DDE		9	ug/kg	1.33
RF3	1	Vermilion rockfish	Muscle	p,-p-DDMU	E	0.4	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 118	E	0.3	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 153/168	E	0.5	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 187	E	0.3	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 99 E		0.3	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Selenium		0.198	mg/kg	0.06
RF3	1	Vermilion rockfish	Muscle	Tin		0.69	mg/kg	0.24
RF3	1	Vermilion rockfish	Muscle	Total DDT		9	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Total PCB		1.6	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Total Solids		21.4	wt%	0.4
RF3	1	Vermilion rockfish	Muscle	Zinc		4.1	mg/kg	0.049
RF3	2	Brown rockfish	Muscle	Aluminum		6.42	mg/kg	0.583
RF3	2	Brown rockfish	Muscle	Arsenic		0.943	mg/kg	0.375
RF3	2	Brown rockfish	Muscle	Barium		0.023	mg/kg	0.007
RF3	2	Brown rockfish	Muscle	Beryllium		0.015	mg/kg	0.003
RF3	2	Brown rockfish	Muscle	Chromium		0.11	mg/kg	0.08
RF3	2	Brown rockfish	Muscle	Copper		0.321	mg/kg	0.068
RF3	2	Brown rockfish	Muscle	Iron		2.76	mg/kg	0.096
RF3	2	Brown rockfish	Muscle	Lipids		0.36	wt%	0.005
RF3	2	Brown rockfish	Muscle	Manganese		0.067	mg/kg	0.007
RF3	2	Brown rockfish	Muscle	Mercury		0.209	mg/kg	0.03
RF3	2	Brown rockfish	Muscle	p,p-DDE		2.5	ug/kg	1.33
RF3	2	Brown rockfish	Muscle	PCB 118	E	0.2	ug/kg	
RF3	2	Brown rockfish	Muscle	PCB 153/168	E	0.3	ug/kg	
RF3	2	Brown rockfish	Muscle	Selenium		0.157	mg/kg	0.06
RF3	2	Brown rockfish	Muscle	Tin		0.756	mg/kg	0.24
RF3	2	Brown rockfish	Muscle	Total DDT		2.5	ug/kg	
RF3	2	Brown rockfish	Muscle	Total PCB		0.5	ug/kg	
RF3	2	Brown rockfish	Muscle	Total Solids		20.7	wt%	0.4
RF3	2	Brown rockfish	Muscle	Zinc		4.66	mg/kg	0.049
RF3	3	Vermilion rockfish	Muscle	Aluminum		4.75	mg/kg	0.583
RF3	3	Vermilion rockfish	Muscle	Arsenic		1.86	mg/kg	0.375
RF3	3	Vermilion rockfish	Muscle	Barium		0.02	mg/kg	0.007
RF3	3	Vermilion rockfish	Muscle	Beryllium		0.013	mg/kg	0.003
RF3	3	Vermilion rockfish	Muscle	Copper		0.143	mg/kg	0.068
RF3	3	Vermilion rockfish	Muscle	Iron		1.61	mg/kg	0.096
RF3	3	Vermilion rockfish	Muscle	Lipids		0.38	wt%	0.005
RF3	3	Vermilion rockfish	Muscle	Manganese		0.095	mg/kg	0.007
RF3	3	Vermilion rockfish	Muscle	Mercury		0.061	mg/kg	0.03
RF3	3	Vermilion rockfish	Muscle	Selenium		0.161	mg/kg	0.06
RF3	3	Vermilion rockfish	Muscle	Tin		0.715	mg/kg	0.24
RF3	3	Vermilion rockfish	Muscle	Total DDT		1	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Total Solids		20.4	wt%	0.4
RF3	3	Vermilion rockfish	Muscle	Zinc		2.7	mg/kg	0.049
RF4	1	Ca. scorpionfish	Muscle	Aluminum		5.7	mg/kg	0.583

Appendix D.3 *continued*
April 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	1	Ca. scorpionfish	Muscle	Arsenic		5.43	mg/kg	0.375
RF4	1	Ca. scorpionfish	Muscle	Barium		0.014	mg/kg	0.007
RF4	1	Ca. scorpionfish	Muscle	Beryllium		0.015	mg/kg	0.003
RF4	1	Ca. scorpionfish	Muscle	Copper		0.496	mg/kg	0.068
RF4	1	Ca. scorpionfish	Muscle	Iron		8.35	mg/kg	0.096
RF4	1	Ca. scorpionfish	Muscle	Lipids		0.68	wt%	0.005
RF4	1	Ca. scorpionfish	Muscle	Manganese		0.108	mg/kg	0.007
RF4	1	Ca. scorpionfish	Muscle	Mercury		0.217	mg/kg	0.03
RF4	1	Ca. scorpionfish	Muscle	p,p-DDE		7.3	ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	PCB 118	E	0.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 138	E	0.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 153/168	E	0.5	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Selenium		0.265	mg/kg	0.06
RF4	1	Ca. scorpionfish	Muscle	Tin		0.774	mg/kg	0.24
RF4	1	Ca. scorpionfish	Muscle	Total DDT		7.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total PCB		1	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total Solids		24	wt%	0.4
RF4	1	Ca. scorpionfish	Muscle	Zinc		6.55	mg/kg	0.049
RF4	2	Ca. scorpionfish	Muscle	Aluminum		5.43	mg/kg	0.583
RF4	2	Ca. scorpionfish	Muscle	Arsenic		1.27	mg/kg	0.375
RF4	2	Ca. scorpionfish	Muscle	Barium		0.013	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Beryllium		0.016	mg/kg	0.003
RF4	2	Ca. scorpionfish	Muscle	Copper		0.311	mg/kg	0.068
RF4	2	Ca. scorpionfish	Muscle	Iron		4.44	mg/kg	0.096
RF4	2	Ca. scorpionfish	Muscle	Lipids		0.47	wt%	0.005
RF4	2	Ca. scorpionfish	Muscle	Manganese		0.083	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Mercury		0.101	mg/kg	0.03
RF4	2	Ca. scorpionfish	Muscle	p,p-DDD	E	0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE		47	ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	p,-p-DDMU	E	0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 101	E	0.3	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 105	E	0.3	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 118	E	0.8	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 138	E	0.8	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 153/168	E	0.9	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 180	E	0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 187	E	0.3	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 206	E	0.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 99 E		0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium		0.154	mg/kg	0.06
RF4	2	Ca. scorpionfish	Muscle	Tin		0.8	mg/kg	0.24
RF4	2	Ca. scorpionfish	Muscle	Total DDT		47.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total PCB		4.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total Solids		24.5	wt%	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc		5.48	mg/kg	0.049
RF4	3	Ca. scorpionfish	Muscle	Aluminum		4.93	mg/kg	0.583
RF4	3	Ca. scorpionfish	Muscle	Arsenic		1.93	mg/kg	0.375
RF4	3	Ca. scorpionfish	Muscle	Barium		0.014	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Beryllium		0.014	mg/kg	0.003
RF4	3	Ca. scorpionfish	Muscle	Chromium		0.087	mg/kg	0.08
RF4	3	Ca. scorpionfish	Muscle	Copper		0.112	mg/kg	0.068
RF4	3	Ca. scorpionfish	Muscle	Iron		1.6	mg/kg	0.096
RF4	3	Ca. scorpionfish	Muscle	Lipids		0.41	wt%	0.005
RF4	3	Ca. scorpionfish	Muscle	Manganese		0.065	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Mercury		0.147	mg/kg	0.03
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE		4.7	ug/kg	1.33

Appendix D.3 *continued*

April 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	3	Ca. scorpionfish	Muscle	PCB 101	E	0.3	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 118	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium		0.166	mg/kg	0.06
RF4	3	Ca. scorpionfish	Muscle	Tin		0.711	mg/kg	0.24
RF4	3	Ca. scorpionfish	Muscle	Total DDT		4.7	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total PCB		0.7	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total Solids		20.9	wt%	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc		2.66	mg/kg	0.049
SD16	1	Longfin sanddab	Liver	Aluminum		10.2	mg/kg	0.583
SD16	1	Longfin sanddab	Liver	Arsenic		0.399	mg/kg	0.375
SD16	1	Longfin sanddab	Liver	Barium		0.022	mg/kg	0.007
SD16	1	Longfin sanddab	Liver	Beryllium		0.022	mg/kg	0.003
SD16	1	Longfin sanddab	Liver	Cadmium		1.9	mg/kg	0.029
SD16	1	Longfin sanddab	Liver	Copper		14.7	mg/kg	0.068
SD16	1	Longfin sanddab	Liver	Iron		203	mg/kg	0.096
SD16	1	Longfin sanddab	Liver	Lipids		9.22	wt%	0.005
SD16	1	Longfin sanddab	Liver	Manganese		0.161	mg/kg	0.007
SD16	1	Longfin sanddab	Liver	Mercury		0.108	mg/kg	0.03
SD16	1	Longfin sanddab	Liver	o,p-DDE	E	6.1	ug/kg	
SD16	1	Longfin sanddab	Liver	o,p-DDT	E	1.3	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDD	E	7	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDE		390	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	p,-p-DDMU	E	11	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDT	E	8.3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 101	E	5.3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 105	E	3.4	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 110	E	3.1	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 118	E	13	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 128	E	4.3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 138		26	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 149	E	3.5	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 151	E	3.2	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 153/168		43	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 156	E	2.6	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 167	E	1.5	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 170	E	6.7	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 180		20	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 183	E	5.4	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 187		21	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 194	E	4.7	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 201	E	4.3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 206	E	3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 66 E		1.4	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 74 E		1.2	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 99 E		8.5	ug/kg	
SD16	1	Longfin sanddab	Liver	Selenium		0.978	mg/kg	0.06
SD16	1	Longfin sanddab	Liver	Silver		0.216	mg/kg	0.057
SD16	1	Longfin sanddab	Liver	Tin		0.915	mg/kg	0.24
SD16	1	Longfin sanddab	Liver	Total DDT		412.7	ug/kg	
SD16	1	Longfin sanddab	Liver	Total PCB		185.1	ug/kg	
SD16	1	Longfin sanddab	Liver	Total Solids		31.7	wt%	0.4
SD16	1	Longfin sanddab	Liver	Zinc		53.6	mg/kg	0.049
SD16	2	Ca. scorpionfish	Liver	Aluminum		10.9	mg/kg	0.583
SD16	2	Ca. scorpionfish	Liver	Arsenic		15.8	mg/kg	0.375
SD16	2	Ca. scorpionfish	Liver	Barium		0.035	mg/kg	0.007

Appendix D.3 *continued*

April 2004

Station	Rep	Species	Tissue	Parameter	Value	Units	MDL
SD16	2	Ca. scorpionfish	Liver	Beryllium	0.028	mg/kg	0.003
SD16	2	Ca. scorpionfish	Liver	Cadmium	5.88	mg/kg	0.029
SD16	2	Ca. scorpionfish	Liver	Chromium	0.153	mg/kg	0.08
SD16	2	Ca. scorpionfish	Liver	Copper	10	mg/kg	0.068
SD16	2	Ca. scorpionfish	Liver	Iron	236	mg/kg	0.096
SD16	2	Ca. scorpionfish	Liver	Lipids	24.9	wt%	0.005
SD16	2	Ca. scorpionfish	Liver	Manganese	1.93	mg/kg	0.007
SD16	2	Ca. scorpionfish	Liver	Mercury	0.111	mg/kg	0.03
SD16	2	Ca. scorpionfish	Liver	p,p-DDD	19	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,p-DDE	600	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,-p-DDMU E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	p,p-DDT E	5.7	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 101 E	8.8	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 105 E	6.8	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 110 E	5	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 118	23	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 123 E	2.8	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 128 E	6.5	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 138	38	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 149 E	5.8	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 151 E	4.1	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 153/168	58	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 156 E	4.4	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 158 E	1.9	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 167 E	1.7	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 170 E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 177 E	5.2	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 180	30	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 183 E	6.6	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 187	25	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 194 E	5.3	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 201 E	5.7	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 206 E	3.1	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 52 E	2	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 66 E	3.1	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 74 E	1.4	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 99 E	10	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Selenium	0.84	mg/kg	0.06
SD16	2	Ca. scorpionfish	Liver	Silver	0.338	mg/kg	0.057
SD16	2	Ca. scorpionfish	Liver	Tin	1.29	mg/kg	0.24
SD16	2	Ca. scorpionfish	Liver	Total DDT	624.7	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Total PCB	276.2	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Total Solids	39.7	wt%	0.4
SD16	2	Ca. scorpionfish	Liver	Trans Nonachlor E	11	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Zinc	33.8	mg/kg	0.049
SD17	1	Longfin sanddab	Liver	Aluminum	10.7	mg/kg	0.583
SD17	1	Longfin sanddab	Liver	Arsenic	7.81	mg/kg	0.375
SD17	1	Longfin sanddab	Liver	Barium	0.034	mg/kg	0.007
SD17	1	Longfin sanddab	Liver	Beryllium	0.026	mg/kg	0.003
SD17	1	Longfin sanddab	Liver	Cadmium	2.53	mg/kg	0.029
SD17	1	Longfin sanddab	Liver	Chromium	0.233	mg/kg	0.08
SD17	1	Longfin sanddab	Liver	Copper	7.35	mg/kg	0.068
SD17	1	Longfin sanddab	Liver	Hexachlorobenzene E	4.4	ug/kg	
SD17	1	Longfin sanddab	Liver	Iron	105	mg/kg	0.096
SD17	1	Longfin sanddab	Liver	Lipids	14.4	wt%	0.005
SD17	1	Longfin sanddab	Liver	Manganese	1.7	mg/kg	0.007

Appendix D.3 *continued*
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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	1	Longfin sanddab	Liver	Mercury		0.107	mg/kg	0.03
SD17	1	Longfin sanddab	Liver	o,p-DDE	E	9.8	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDD		14	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDE		710	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,-p-DDMU		20	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDT	E	12	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 101	E	4.8	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 105	E	5.2	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 110	E	3.4	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 118		21	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 123	E	1.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 128	E	6.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 138		39	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 149	E	4.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 151	E	4.1	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 153/168		57	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 156	E	3.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 170	E	10	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 180		29	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 183	E	8.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 187		30	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 194	E	7.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 201	E	5.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 206	E	4.5	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 66 E		2.2	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 74 E		1.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 99 E		12	ug/kg	
SD17	1	Longfin sanddab	Liver	Selenium		0.99	mg/kg	0.06
SD17	1	Longfin sanddab	Liver	Silver		0.204	mg/kg	0.057
SD17	1	Longfin sanddab	Liver	Tin		1.09	mg/kg	0.24
SD17	1	Longfin sanddab	Liver	Total DDT		745.8	ug/kg	
SD17	1	Longfin sanddab	Liver	Total PCB		263.8	ug/kg	
SD17	1	Longfin sanddab	Liver	Total Solids		37	wt%	0.4
SD17	1	Longfin sanddab	Liver	Zinc		28.5	mg/kg	0.049
SD17	2	Pacific sanddab	Liver	Aluminum		9.53	mg/kg	0.583
SD17	2	Pacific sanddab	Liver	Arsenic		0.725	mg/kg	0.375
SD17	2	Pacific sanddab	Liver	Barium		0.024	mg/kg	0.007
SD17	2	Pacific sanddab	Liver	Beryllium		0.023	mg/kg	0.003
SD17	2	Pacific sanddab	Liver	Cadmium		1.13	mg/kg	0.029
SD17	2	Pacific sanddab	Liver	Copper		11.9	mg/kg	0.068
SD17	2	Pacific sanddab	Liver	Iron		95.6	mg/kg	0.096
SD17	2	Pacific sanddab	Liver	Lipids		11.4	wt%	0.005
SD17	2	Pacific sanddab	Liver	Manganese		0.363	mg/kg	0.007
SD17	2	Pacific sanddab	Liver	Mercury		0.078	mg/kg	0.03
SD17	2	Pacific sanddab	Liver	o,p-DDE	E	6.7	ug/kg	
SD17	2	Pacific sanddab	Liver	p,p-DDD	E	12	ug/kg	
SD17	2	Pacific sanddab	Liver	p,p-DDE		500	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	p,-p-DDMU		19	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	p,p-DDT	E	13	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 101	E	5.3	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 105	E	5.2	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 110	E	4.4	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 118		18	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	PCB 128	E	6.1	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 138		33	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	PCB 149	E	7.1	ug/kg	

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	2	Pacific sanddab	Liver	PCB 151	E	2.7	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 153/168		45	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	PCB 156	E	3.4	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 158	E	2.1	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 170	E	9.4	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 177	E	3.2	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 180		26	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	PCB 183	E	6.5	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 187		22	ug/kg	13.3
SD17	2	Pacific sanddab	Liver	PCB 194	E	5.2	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 201	E	4.1	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 206	E	2.9	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 66 E		1.6	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 70 E		1.2	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 74 E		1.3	ug/kg	
SD17	2	Pacific sanddab	Liver	PCB 99 E		9.9	ug/kg	
SD17	2	Pacific sanddab	Liver	Selenium		0.823	mg/kg	0.06
SD17	2	Pacific sanddab	Liver	Silver		0.326	mg/kg	0.057
SD17	2	Pacific sanddab	Liver	Tin		0.958	mg/kg	0.24
SD17	2	Pacific sanddab	Liver	Total DDT		531.7	ug/kg	
SD17	2	Pacific sanddab	Liver	Total PCB		225.6	ug/kg	
SD17	2	Pacific sanddab	Liver	Total Solids		32.3	wt%	0.4
SD17	2	Pacific sanddab	Liver	Trans Nonachlor E		6.4	ug/kg	
SD17	2	Pacific sanddab	Liver	Zinc		94.2	mg/kg	0.049
SD17	3	Ca. scorpionfish	Liver	Aluminum		16.1	mg/kg	0.583
SD17	3	Ca. scorpionfish	Liver	Arsenic		7.82	mg/kg	0.375
SD17	3	Ca. scorpionfish	Liver	Barium		0.061	mg/kg	0.007
SD17	3	Ca. scorpionfish	Liver	Beryllium		0.034	mg/kg	0.003
SD17	3	Ca. scorpionfish	Liver	Cadmium		4.57	mg/kg	0.029
SD17	3	Ca. scorpionfish	Liver	Chromium		0.685	mg/kg	0.08
SD17	3	Ca. scorpionfish	Liver	Copper		9.01	mg/kg	0.068
SD17	3	Ca. scorpionfish	Liver	Iron		221	mg/kg	0.096
SD17	3	Ca. scorpionfish	Liver	Lead		0.394	mg/kg	0.3
SD17	3	Ca. scorpionfish	Liver	Lipids		17.3	wt%	0.005
SD17	3	Ca. scorpionfish	Liver	Manganese		2.09	mg/kg	0.007
SD17	3	Ca. scorpionfish	Liver	Mercury		0.28	mg/kg	0.03
SD17	3	Ca. scorpionfish	Liver	Nickel		0.102	mg/kg	0.094
SD17	3	Ca. scorpionfish	Liver	o,p-DDE	E	5	ug/kg	
SD17	3	Ca. scorpionfish	Liver	p,p-DDD		27	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	p,p-DDE		1500	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	p,-p-DDMU		19	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	p,p-DDT	E	6.65	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 101	E	12.5	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 105	E	8.15	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 110	E	9.9	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 118		32.5	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 123	E	3.15	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 128	E	7.15	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 138		34.5	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 149	E	7.85	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 151	<	13.3	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 153/168		50.5	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 156	E	4.05	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 167	<	13.3	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 170	E	6.7	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 180		20.5	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	3	Ca. scorpionfish	Liver	PCB 183	E	5.55	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 187		20	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 194	E	4.6	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 201	E	4.9	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 206	E	3.65	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 52 E		4.1	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 66 E		5.35	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 74 E		3.25	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 99 E		13	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Selenium		0.756	mg/kg	0.06
SD17	3	Ca. scorpionfish	Liver	Silver		0.247	mg/kg	0.057
SD17	3	Ca. scorpionfish	Liver	Tin		1.57	mg/kg	0.24
SD17	3	Ca. scorpionfish	Liver	Total DDT		1538.7	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Total PCB		288.5	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Total Solids		52.1	wt%	0.4
SD17	3	Ca. scorpionfish	Liver	Zinc		42.9	mg/kg	0.049
SD18	1	Longfin sanddab	Liver	Aluminum		9.99	mg/kg	0.583
SD18	1	Longfin sanddab	Liver	Arsenic		19.8	mg/kg	0.375
SD18	1	Longfin sanddab	Liver	Barium		0.086	mg/kg	0.007
SD18	1	Longfin sanddab	Liver	Beryllium		0.026	mg/kg	0.003
SD18	1	Longfin sanddab	Liver	Cadmium		5.12	mg/kg	0.029
SD18	1	Longfin sanddab	Liver	Chromium		0.115	mg/kg	0.08
SD18	1	Longfin sanddab	Liver	Copper		11.4	mg/kg	0.068
SD18	1	Longfin sanddab	Liver	Iron		235	mg/kg	0.096
SD18	1	Longfin sanddab	Liver	Lipids		24.2	wt%	0.005
SD18	1	Longfin sanddab	Liver	Manganese		1.22	mg/kg	0.007
SD18	1	Longfin sanddab	Liver	Mercury		0.184	mg/kg	0.03
SD18	1	Longfin sanddab	Liver	Mirex E		3.4	ug/kg	
SD18	1	Longfin sanddab	Liver	Nickel		0.095	mg/kg	0.094
SD18	1	Longfin sanddab	Liver	o,p-DDD	E	1.9	ug/kg	
SD18	1	Longfin sanddab	Liver	o,p-DDE	E	11	ug/kg	
SD18	1	Longfin sanddab	Liver	o,p-DDT	E	3.9	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDD		25	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	p,p-DDE		1100	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	p,-p-DDMU		26	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	p,p-DDT		29	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 101	E	6.8	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 105	E	13	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 110	E	5.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 118		49	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 123	E	4.4	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 128		17	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 138		100	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 149	E	7.3	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 151	E	8.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 153/168		150	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 156	E	9.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 157	E	1.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 158	E	5.5	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 167	E	5.5	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 170		28	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 177	E	9.6	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 180		76	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 183		22	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 187		72	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 194		18	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	1	Longfin sanddab	Liver	PCB 201	E	13	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 206	E	9.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 66 E		3.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 74 E		2.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 99		27	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	Selenium		1.95	mg/kg	0.06
SD18	1	Longfin sanddab	Liver	Silver		0.382	mg/kg	0.057
SD18	1	Longfin sanddab	Liver	Tin		1.14	mg/kg	0.24
SD18	1	Longfin sanddab	Liver	Total DDT		1170.8	ug/kg	
SD18	1	Longfin sanddab	Liver	Total PCB		664.5	ug/kg	
SD18	1	Longfin sanddab	Liver	Total Solids		34.7	wt%	0.4
SD18	1	Longfin sanddab	Liver	Trans Nonachlor E		11	ug/kg	
SD18	1	Longfin sanddab	Liver	Zinc		29.7	mg/kg	0.049
SD18	2	Longfin sanddab	Liver	Aluminum		8.86	mg/kg	0.583
SD18	2	Longfin sanddab	Liver	Arsenic		11.4	mg/kg	0.375
SD18	2	Longfin sanddab	Liver	Barium		0.022	mg/kg	0.007
SD18	2	Longfin sanddab	Liver	Beryllium		0.022	mg/kg	0.003
SD18	2	Longfin sanddab	Liver	Cadmium		5.19	mg/kg	0.029
SD18	2	Longfin sanddab	Liver	Chromium		0.104	mg/kg	0.08
SD18	2	Longfin sanddab	Liver	Copper		8.94	mg/kg	0.068
SD18	2	Longfin sanddab	Liver	Iron		202	mg/kg	0.096
SD18	2	Longfin sanddab	Liver	Lead		0.307	mg/kg	0.3
SD18	2	Longfin sanddab	Liver	Lipids		16.8	wt%	0.005
SD18	2	Longfin sanddab	Liver	Manganese		1.66	mg/kg	0.007
SD18	2	Longfin sanddab	Liver	Mercury		0.159	mg/kg	0.03
SD18	2	Longfin sanddab	Liver	o,p-DDD	E	2.3	ug/kg	
SD18	2	Longfin sanddab	Liver	o,p-DDE		14	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	o,p-DDT	E	3.1	ug/kg	
SD18	2	Longfin sanddab	Liver	p,p-DDD		25	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	p,p-DDE		910	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	p,-p-DDMU		30	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	p,p-DDT		19	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 101	E	6.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 105	E	6.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 110	E	5.5	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 118		26	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 123	E	2.7	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 128	E	8.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 138		48	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 149	E	7	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 151	E	6.3	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 153/168		77	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 156	E	4.3	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 158	E	2.4	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 167	E	2.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 170		16	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 177	E	6.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 180		41	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 183	E	12	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 187		43	ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 194	E	12	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 201	E	8.1	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 206	E	6.7	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 66 E		2.7	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 74 E		1.9	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 99		14	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	2	Longfin sanddab	Liver	Selenium		1.62	mg/kg	0.06
SD18	2	Longfin sanddab	Liver	Silver		0.281	mg/kg	0.057
SD18	2	Longfin sanddab	Liver	Tin		0.992	mg/kg	0.24
SD18	2	Longfin sanddab	Liver	Total DDT		973.4	ug/kg	
SD18	2	Longfin sanddab	Liver	Total PCB		369.1	ug/kg	
SD18	2	Longfin sanddab	Liver	Total Solids		30.6	wt%	0.4
SD18	2	Longfin sanddab	Liver	Zinc		28.6	mg/kg	0.049
SD18	3	Hornyhead turbot	Liver	Aluminum		6.64	mg/kg	0.583
SD18	3	Hornyhead turbot	Liver	Arsenic		3.59	mg/kg	0.375
SD18	3	Hornyhead turbot	Liver	Barium		0.014	mg/kg	0.007
SD18	3	Hornyhead turbot	Liver	Beryllium		0.017	mg/kg	0.003
SD18	3	Hornyhead turbot	Liver	Cadmium		6.81	mg/kg	0.029
SD18	3	Hornyhead turbot	Liver	Chromium		0.111	mg/kg	0.08
SD18	3	Hornyhead turbot	Liver	Copper		4.67	mg/kg	0.068
SD18	3	Hornyhead turbot	Liver	Iron		43.5	mg/kg	0.096
SD18	3	Hornyhead turbot	Liver	Lipids		8.64	wt%	0.005
SD18	3	Hornyhead turbot	Liver	Manganese		1.12	mg/kg	0.007
SD18	3	Hornyhead turbot	Liver	Mercury		0.141	mg/kg	0.03
SD18	3	Hornyhead turbot	Liver	p,p-DDD	E	8.3	ug/kg	
SD18	3	Hornyhead turbot	Liver	p,p-DDE		150	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	p,-p-DDMU	E	11	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 101	E	1.9	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 118	E	2.6	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 138	E	6.1	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 153/168	E	6.5	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 180	E	4.4	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 187	E	3.5	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 99 E		1.6	ug/kg	
SD18	3	Hornyhead turbot	Liver	Selenium		0.495	mg/kg	0.06
SD18	3	Hornyhead turbot	Liver	Silver		0.191	mg/kg	0.057
SD18	3	Hornyhead turbot	Liver	Tin		0.839	mg/kg	0.24
SD18	3	Hornyhead turbot	Liver	Total DDT		158.3	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total PCB		26.6	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total Solids		30.4	wt%	0.4
SD18	3	Hornyhead turbot	Liver	Zinc		39.6	mg/kg	0.049
SD19	1	Hornyhead turbot	Liver	Aluminum		7.76	mg/kg	0.583
SD19	1	Hornyhead turbot	Liver	Arsenic		2.47	mg/kg	0.375
SD19	1	Hornyhead turbot	Liver	Barium		0.021	mg/kg	0.007
SD19	1	Hornyhead turbot	Liver	Beryllium		0.02	mg/kg	0.003
SD19	1	Hornyhead turbot	Liver	Cadmium		4.63	mg/kg	0.029
SD19	1	Hornyhead turbot	Liver	Chromium		0.1	mg/kg	0.08
SD19	1	Hornyhead turbot	Liver	Copper		5.94	mg/kg	0.068
SD19	1	Hornyhead turbot	Liver	Iron		38.5	mg/kg	0.096
SD19	1	Hornyhead turbot	Liver	Lipids		6.49	wt%	0.005
SD19	1	Hornyhead turbot	Liver	Manganese		1.41	mg/kg	0.007
SD19	1	Hornyhead turbot	Liver	Mercury		0.123	mg/kg	0.03
SD19	1	Hornyhead turbot	Liver	p,p-DDD	E	6.1	ug/kg	
SD19	1	Hornyhead turbot	Liver	p,p-DDE		150	ug/kg	13.3
SD19	1	Hornyhead turbot	Liver	p,-p-DDMU	E	6.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 118	E	6.9	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 138	E	11	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 153/168		14	ug/kg	13.3
SD19	1	Hornyhead turbot	Liver	PCB 180	E	8.2	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 183	E	3	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 187	E	7.4	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 99 E		3.2	ug/kg	

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	1	Hornyhead turbot	Liver	Selenium		0.613	mg/kg	0.06
SD19	1	Hornyhead turbot	Liver	Silver		0.148	mg/kg	0.057
SD19	1	Hornyhead turbot	Liver	Tin		0.922	mg/kg	0.24
SD19	1	Hornyhead turbot	Liver	Total DDT		156.1	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total PCB		53.7	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total Solids		27.8	wt%	0.4
SD19	1	Hornyhead turbot	Liver	Zinc		37.1	mg/kg	0.049
SD20	1	Longfin sanddab	Liver	Aluminum		8.42	mg/kg	0.583
SD20	1	Longfin sanddab	Liver	Arsenic		9.89	mg/kg	0.375
SD20	1	Longfin sanddab	Liver	Barium		0.023	mg/kg	0.007
SD20	1	Longfin sanddab	Liver	Beryllium		0.022	mg/kg	0.003
SD20	1	Longfin sanddab	Liver	Cadmium		4.93	mg/kg	0.029
SD20	1	Longfin sanddab	Liver	Chromium		0.109	mg/kg	0.08
SD20	1	Longfin sanddab	Liver	Copper		8.96	mg/kg	0.068
SD20	1	Longfin sanddab	Liver	Iron		212	mg/kg	0.096
SD20	1	Longfin sanddab	Liver	Lipids		11	wt%	0.005
SD20	1	Longfin sanddab	Liver	Manganese		1.35	mg/kg	0.007
SD20	1	Longfin sanddab	Liver	Mercury		0.212	mg/kg	0.03
SD20	1	Longfin sanddab	Liver	o,p-DDE	E	5.6	ug/kg	
SD20	1	Longfin sanddab	Liver	o,p-DDT	E	3	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDD	E	10	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDE		490	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,-p-DDMU		16	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDT		35	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 101		15	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 105	E	11	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 110	E	10	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 118		46	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 123	E	3.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 128	E	8.3	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 138		60	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 149	E	6.6	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 151	E	6.1	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 153/168		84	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 156	E	6.4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 158	E	3.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 167	E	3	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 170	E	12	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 177	E	4.1	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 180		34	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 183	E	8.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 187		31	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 194	E	8.4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 201	E	6.6	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 206	E	5.2	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 52 E		9.6	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 66 E		4.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 70 E		2.4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 74 E		2.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 87 E		2.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 99		26	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	Selenium		1.82	mg/kg	0.06
SD20	1	Longfin sanddab	Liver	Silver		0.277	mg/kg	0.057
SD20	1	Longfin sanddab	Liver	Tin		0.939	mg/kg	0.24
SD20	1	Longfin sanddab	Liver	Total DDT		543.6	ug/kg	
SD20	1	Longfin sanddab	Liver	Total PCB		422.5	ug/kg	

Appendix D.3 *continued*
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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	1	Longfin sanddab	Liver	Total Solids		33.6	wt%	0.4
SD20	1	Longfin sanddab	Liver	Zinc		28.6	mg/kg	0.049
SD20	2	Hornyhead turbot	Liver	Aluminum		7.18	mg/kg	0.583
SD20	2	Hornyhead turbot	Liver	Arsenic		2.71	mg/kg	0.375
SD20	2	Hornyhead turbot	Liver	Barium		0.032	mg/kg	0.007
SD20	2	Hornyhead turbot	Liver	Beryllium		0.018	mg/kg	0.003
SD20	2	Hornyhead turbot	Liver	Cadmium		9.71	mg/kg	0.029
SD20	2	Hornyhead turbot	Liver	Chromium		0.103	mg/kg	0.08
SD20	2	Hornyhead turbot	Liver	Copper		5.66	mg/kg	0.068
SD20	2	Hornyhead turbot	Liver	Iron		62	mg/kg	0.096
SD20	2	Hornyhead turbot	Liver	Lipids		4.53	wt%	0.005
SD20	2	Hornyhead turbot	Liver	Manganese		1.08	mg/kg	0.007
SD20	2	Hornyhead turbot	Liver	Mercury		0.221	mg/kg	0.03
SD20	2	Hornyhead turbot	Liver	Nickel		0.105	mg/kg	0.094
SD20	2	Hornyhead turbot	Liver	p,p-DDE		62	ug/kg	13.3
SD20	2	Hornyhead turbot	Liver	p,-p-DDMU	E	4	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 118	E	1.8	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 153/168	E	4.2	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 180	E	2.1	ug/kg	
SD20	2	Hornyhead turbot	Liver	Selenium		0.902	mg/kg	0.06
SD20	2	Hornyhead turbot	Liver	Silver		0.198	mg/kg	0.057
SD20	2	Hornyhead turbot	Liver	Tin		0.885	mg/kg	0.24
SD20	2	Hornyhead turbot	Liver	Total DDT		62	ug/kg	
SD20	2	Hornyhead turbot	Liver	Total PCB		8.1	ug/kg	
SD20	2	Hornyhead turbot	Liver	Total Solids		26.1	wt%	0.4
SD20	2	Hornyhead turbot	Liver	Zinc		42.6	mg/kg	0.049
SD20	3	Longfin sanddab	Liver	Lipids		7.52	wt%	0.005
SD20	3	Longfin sanddab	Liver	p,p-DDD	E	4.5	ug/kg	
SD20	3	Longfin sanddab	Liver	p,p-DDE		240	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	p,-p-DDMU	E	5.9	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 101	E	2.6	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 110	E	1.5	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 118		19	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	PCB 123	E	1.2	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 128	E	4.1	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 138		29	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	PCB 153/168		34	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	PCB 156	E	3	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 158	E	1.5	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 167	E	1.8	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 170	E	6.7	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 180		17	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	PCB 183	E	5.1	ug/kg	
SD20	3	Longfin sanddab	Liver	PCB 187		15	ug/kg	13.3
SD20	3	Longfin sanddab	Liver	PCB 99 E		8.6	ug/kg	
SD20	3	Longfin sanddab	Liver	Total DDT		244.5	ug/kg	
SD20	3	Longfin sanddab	Liver	Total PCB		150.1	ug/kg	
SD21	1	Hornyhead turbot	Liver	Aluminum		8.7	mg/kg	0.583
SD21	1	Hornyhead turbot	Liver	Arsenic		2.85	mg/kg	0.375
SD21	1	Hornyhead turbot	Liver	Barium		0.065	mg/kg	0.007
SD21	1	Hornyhead turbot	Liver	Beryllium		0.02	mg/kg	0.003
SD21	1	Hornyhead turbot	Liver	Cadmium		5.87	mg/kg	0.029
SD21	1	Hornyhead turbot	Liver	Chromium		0.097	mg/kg	0.08
SD21	1	Hornyhead turbot	Liver	Copper		13.2	mg/kg	0.068
SD21	1	Hornyhead turbot	Liver	Iron		74.6	mg/kg	0.096
SD21	1	Hornyhead turbot	Liver	Lipids		9.08	wt%	0.005

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	1	Hornyhead turbot	Liver	Manganese		1.45	mg/kg	0.007
SD21	1	Hornyhead turbot	Liver	Mercury		0.152	mg/kg	0.03
SD21	1	Hornyhead turbot	Liver	Nickel		0.128	mg/kg	0.094
SD21	1	Hornyhead turbot	Liver	p,p-DDD	E	7.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	p,p-DDE		89	ug/kg	13.3
SD21	1	Hornyhead turbot	Liver	p,-p-DDMU	E	3.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 101	E	3	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 118	E	3	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 138	E	7.1	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 149	E	2.7	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 153/168	E	10	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 180	E	4.6	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 183	E	1.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 187	E	5.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 99 E		2.8	ug/kg	
SD21	1	Hornyhead turbot	Liver	Selenium		0.737	mg/kg	0.06
SD21	1	Hornyhead turbot	Liver	Silver		0.369	mg/kg	0.057
SD21	1	Hornyhead turbot	Liver	Tin		0.827	mg/kg	0.24
SD21	1	Hornyhead turbot	Liver	Total DDT		96.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total PCB		41	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total Solids		27.1	wt%	0.4
SD21	1	Hornyhead turbot	Liver	Zinc		57.4	mg/kg	0.049
SD21	2	Ca. scorpionfish	Liver	Aluminum		12.4	mg/kg	0.583
SD21	2	Ca. scorpionfish	Liver	Arsenic		1.18	mg/kg	0.375
SD21	2	Ca. scorpionfish	Liver	Barium		0.035	mg/kg	0.007
SD21	2	Ca. scorpionfish	Liver	Beryllium		0.032	mg/kg	0.003
SD21	2	Ca. scorpionfish	Liver	Cadmium		1.31	mg/kg	0.029
SD21	2	Ca. scorpionfish	Liver	Copper		14.8	mg/kg	0.068
SD21	2	Ca. scorpionfish	Liver	Iron		166	mg/kg	0.096
SD21	2	Ca. scorpionfish	Liver	Lipids		20	wt%	0.005
SD21	2	Ca. scorpionfish	Liver	Manganese		0.31	mg/kg	0.007
SD21	2	Ca. scorpionfish	Liver	Mercury		0.118	mg/kg	0.03
SD21	2	Ca. scorpionfish	Liver	o,p-DDE	E	1.5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	o,p-DDT	E	23	ug/kg	
SD21	2	Ca. scorpionfish	Liver	p,p-DDD		170	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	p,p-DDE		640	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	p,-p-DDMU	E	11	ug/kg	
SD21	2	Ca. scorpionfish	Liver	p,p-DDT		120	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 101		15	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 105	E	12	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 110	E	10	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 118		38	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 123	E	4.3	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 128	E	12	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 138		54	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 149	E	10	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 151	E	6.7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 153/168		80	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 156	E	7.2	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 157	E	1.7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 167	E	3.5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 170		16	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 177	E	7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 180		46	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 183	E	12	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 187		36	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	2	Ca. scorpionfish	Liver	PCB 194	E	9.1	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 201	E	8.4	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 206	E	5.1	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 52 E		4.9	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 66 E		6	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 70 E		1.5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 74 E		2.7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 87 E		3.6	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 99		22	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	Selenium		0.87	mg/kg	0.06
SD21	2	Ca. scorpionfish	Liver	Silver		0.259	mg/kg	0.057
SD21	2	Ca. scorpionfish	Liver	Tin		1.49	mg/kg	0.24
SD21	2	Ca. scorpionfish	Liver	Total DDT		954.5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Total PCB		434.7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Total Solids		50.2	wt%	0.4
SD21	2	Ca. scorpionfish	Liver	Trans Nonachlor E		10	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Zinc		66.7	mg/kg	0.049
SD21	3	Longfin sanddab	Liver	Aluminum		9	mg/kg	0.583
SD21	3	Longfin sanddab	Liver	Arsenic		6.58	mg/kg	0.375
SD21	3	Longfin sanddab	Liver	Barium		0.028	mg/kg	0.007
SD21	3	Longfin sanddab	Liver	Beryllium		0.021	mg/kg	0.003
SD21	3	Longfin sanddab	Liver	Cadmium		3.86	mg/kg	0.029
SD21	3	Longfin sanddab	Liver	Chromium		0.141	mg/kg	0.08
SD21	3	Longfin sanddab	Liver	Copper		11.5	mg/kg	0.068
SD21	3	Longfin sanddab	Liver	Iron		144	mg/kg	0.096
SD21	3	Longfin sanddab	Liver	Lead		0.542	mg/kg	0.3
SD21	3	Longfin sanddab	Liver	Lipids		8.2	wt%	0.005
SD21	3	Longfin sanddab	Liver	Manganese		1.8	mg/kg	0.007
SD21	3	Longfin sanddab	Liver	Mercury		0.13	mg/kg	0.03
SD21	3	Longfin sanddab	Liver	o,p-DDE	E	5.2	ug/kg	
SD21	3	Longfin sanddab	Liver	o,p-DDT	E	3.4	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDD	E	9.5	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDE		350	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	p,-p-DDMU	E	10	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDT		37	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 101	E	3.7	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 105	E	5.1	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 110	E	3.7	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 118		22	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 123	E	2.5	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 128	E	7.7	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 138		39	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 149	E	3.9	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 151	E	3.9	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 153/168		53	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 156	E	4.2	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 158	E	2	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 167	E	2.2	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 170	E	7.4	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 177	E	3	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 180		23	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 183	E	7.7	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 187		26	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 194	E	6.8	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 201	E	6	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 206	E	4.9	ug/kg	

Station	Rep	Species	Tissue	Parameter	Value	Units	MDL
SD21	3	Longfin sanddab	Liver	PCB 66 E	1.6	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 74 E	1.2	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 99	14	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	Selenium	1.16	mg/kg	0.06
SD21	3	Longfin sanddab	Liver	Silver	0.38	mg/kg	0.057
SD21	3	Longfin sanddab	Liver	Tin	0.875	mg/kg	0.24
SD21	3	Longfin sanddab	Liver	Total DDT	405.1	ug/kg	
SD21	3	Longfin sanddab	Liver	Total PCB	254.5	ug/kg	
SD21	3	Longfin sanddab	Liver	Total Solids	30.8	wt%	0.4
SD21	3	Longfin sanddab	Liver	Zinc	31.7	mg/kg	0.049

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF3	1	Brown rockfish	Muscle	Arsenic		1.01	mg/kg	0.375
RF3	1	Brown rockfish	Muscle	Barium		0.021	mg/kg	0.007
RF3	1	Brown rockfish	Muscle	Chromium		0.177	mg/kg	0.08
RF3	1	Brown rockfish	Muscle	Copper		0.198	mg/kg	0.068
RF3	1	Brown rockfish	Muscle	Hexachlorobenzene	E	0.1	ug/kg	
RF3	1	Brown rockfish	Muscle	Iron		1.27	mg/kg	0.096
RF3	1	Brown rockfish	Muscle	Lipids		0.38	wt%	0.005
RF3	1	Brown rockfish	Muscle	Manganese		0.074	mg/kg	0.007
RF3	1	Brown rockfish	Muscle	Mercury		0.206	mg/kg	0.03
RF3	1	Brown rockfish	Muscle	p,p-DDD	E	0.2	ug/kg	
RF3	1	Brown rockfish	Muscle	p,p-DDE		12	ug/kg	1.33
RF3	1	Brown rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 105	E	0.1	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 118	E	0.4	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 138	E	0.6	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 153/168	E	1	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 180	E	0.4	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 187	E	0.3	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 66	E	0.1	ug/kg	
RF3	1	Brown rockfish	Muscle	PCB 99	E	0.3	ug/kg	
RF3	1	Brown rockfish	Muscle	Selenium		0.316	mg/kg	0.06
RF3	1	Brown rockfish	Muscle	Tin		0.45	mg/kg	0.24
RF3	1	Vermilion rockfish	Muscle	Total DDT		9	ug/kg	
RF3	1	Brown rockfish	Muscle	Total DDT		12.2	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Total PCB		1.6	ug/kg	
RF3	1	Brown rockfish	Muscle	Total PCB		3.4	ug/kg	
RF3	1	Brown rockfish	Muscle	Total Solids		21.4	wt%	0.4
RF3	1	Brown rockfish	Muscle	Zinc		3.71	mg/kg	0.049
RF3	2	Brown rockfish	Muscle	Arsenic		1.74	mg/kg	0.375
RF3	2	Brown rockfish	Muscle	Barium		0.017	mg/kg	0.007
RF3	2	Brown rockfish	Muscle	Chromium		0.138	mg/kg	0.08
RF3	2	Brown rockfish	Muscle	Copper		0.185	mg/kg	0.068
RF3	2	Brown rockfish	Muscle	Iron		0.89	mg/kg	0.096
RF3	2	Brown rockfish	Muscle	Lipids		0.45	wt%	0.005
RF3	2	Brown rockfish	Muscle	Manganese		0.062	mg/kg	0.007
RF3	2	Brown rockfish	Muscle	Mercury		0.168	mg/kg	0.03
RF3	2	Brown rockfish	Muscle	p,p-DDE		4.3	ug/kg	1.33
RF3	2	Brown rockfish	Muscle	PCB 118	E	0.3	ug/kg	
RF3	2	Brown rockfish	Muscle	PCB 138	E	0.4	ug/kg	
RF3	2	Brown rockfish	Muscle	PCB 153/168	E	0.6	ug/kg	
RF3	2	Brown rockfish	Muscle	Selenium		0.301	mg/kg	0.06
RF3	2	Brown rockfish	Muscle	Tin		0.321	mg/kg	0.24
RF3	2	Brown rockfish	Muscle	Total DDT		2.5	ug/kg	
RF3	2	Brown rockfish	Muscle	Total DDT		4.3	ug/kg	
RF3	2	Brown rockfish	Muscle	Total PCB		0.5	ug/kg	
RF3	2	Brown rockfish	Muscle	Total PCB		1.3	ug/kg	
RF3	2	Brown rockfish	Muscle	Total Solids		21	wt%	0.4
RF3	2	Brown rockfish	Muscle	Zinc		3.63	mg/kg	0.049
RF3	3	Vermilion rockfish	Muscle	Arsenic		2.57	mg/kg	0.375
RF3	3	Vermilion rockfish	Muscle	Barium		0.02	mg/kg	0.007
RF3	3	Vermilion rockfish	Muscle	Chromium		0.165	mg/kg	0.08
RF3	3	Vermilion rockfish	Muscle	Copper		0.288	mg/kg	0.068
RF3	3	Vermilion rockfish	Muscle	Hexachlorobenzene	E	0.1	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Iron		1.45	mg/kg	0.096

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF3	3	Vermilion rockfish	Muscle	Lipids		0.91	wt%	0.005
RF3	3	Vermilion rockfish	Muscle	Manganese		0.095	mg/kg	0.007
RF3	3	Vermilion rockfish	Muscle	Mercury		0.058	mg/kg	0.03
RF3	3	Vermilion rockfish	Muscle	p,p-DDD	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	p,p-DDE		4.9	ug/kg	1.33
RF3	3	Vermilion rockfish	Muscle	p,-p-DDMU	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 118	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 138	E	0.4	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 153/168	E	0.6	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 99	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Selenium		0.307	mg/kg	0.06
RF3	3	Vermilion rockfish	Muscle	Tin		0.299	mg/kg	0.24
RF3	3	Vermilion rockfish	Muscle	Total DDT		1	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Total DDT		5.1	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Total PCB		1.6	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Total Solids		21.9	wt%	0.4
RF3	3	Vermilion rockfish	Muscle	Zinc		3.5	mg/kg	0.049
RF4	1	Ca. scorpionfish	Muscle	Aluminum		0.931	mg/kg	0.583
RF4	1	Ca. scorpionfish	Muscle	Arsenic		2.19	mg/kg	0.375
RF4	1	Ca. scorpionfish	Muscle	Barium		0.015	mg/kg	0.007
RF4	1	Ca. scorpionfish	Muscle	Chromium		0.149	mg/kg	0.08
RF4	1	Ca. scorpionfish	Muscle	Copper		0.13	mg/kg	0.068
RF4	1	Ca. scorpionfish	Muscle	Iron		1.92	mg/kg	0.096
RF4	1	Ca. scorpionfish	Muscle	Lipids		0.19	wt%	0.005
RF4	1	Ca. scorpionfish	Muscle	Manganese		0.099	mg/kg	0.007
RF4	1	Ca. scorpionfish	Muscle	Mercury		0.16	mg/kg	0.03
RF4	1	Ca. scorpionfish	Muscle	p,p-DDE		7.6	ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	PCB 101	E	0.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 118	E	0.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 153/168	E	0.6	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 99	E	0.1	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Selenium		0.192	mg/kg	0.06
RF4	1	Ca. scorpionfish	Muscle	Tin		0.351	mg/kg	0.24
RF4	1	Ca. scorpionfish	Muscle	Total DDT		7.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total DDT		7.6	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total PCB		1	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total PCB		1.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Total Solids		20.6	wt%	0.4
RF4	1	Ca. scorpionfish	Muscle	Zinc		4.24	mg/kg	0.049
RF4	2	Ca. scorpionfish	Muscle	Arsenic		2.11	mg/kg	0.375
RF4	2	Ca. scorpionfish	Muscle	Barium		0.016	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Chromium		0.127	mg/kg	0.08
RF4	2	Ca. scorpionfish	Muscle	Copper		0.186	mg/kg	0.068
RF4	2	Ca. scorpionfish	Muscle	Hexachlorobenzene	E	0.1	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Iron		2.34	mg/kg	0.096
RF4	2	Ca. scorpionfish	Muscle	Lipids		0.92	wt%	0.005
RF4	2	Ca. scorpionfish	Muscle	Manganese		0.076	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Mercury		0.134	mg/kg	0.03
RF4	2	Ca. scorpionfish	Muscle	p,p-DDD	E	0.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE		11	ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	p,-p-DDMU	E	0.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 101	E	0.2	ug/kg	

Appendix D.3 *continued*

October 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	2	Ca. scorpionfish	Muscle	PCB 118	E	0.3	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 153/168	E	0.7	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 180	E	0.3	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 99	E	0.1	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium		0.236	mg/kg	0.06
RF4	2	Ca. scorpionfish	Muscle	Tin		0.369	mg/kg	0.24
RF4	2	Ca. scorpionfish	Muscle	Total DDT		47.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total DDT		11.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total PCB		4.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total PCB		1.6	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Total Solids		20.2	wt%	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc		3.49	mg/kg	0.049
RF4	3	Ca. scorpionfish	Muscle	Arsenic		2.04	mg/kg	0.375
RF4	3	Ca. scorpionfish	Muscle	Barium		0.014	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Chromium		0.124	mg/kg	0.08
RF4	3	Ca. scorpionfish	Muscle	Copper		0.155	mg/kg	0.068
RF4	3	Ca. scorpionfish	Muscle	Iron		2.15	mg/kg	0.096
RF4	3	Ca. scorpionfish	Muscle	Lipids		0.24	wt%	0.005
RF4	3	Ca. scorpionfish	Muscle	Manganese		0.091	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Mercury		0.181	mg/kg	0.03
RF4	3	Ca. scorpionfish	Muscle	p,p-DDD	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE		9.9	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	E	0.5	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium		0.167	mg/kg	0.06
RF4	3	Ca. scorpionfish	Muscle	Tin		0.398	mg/kg	0.24
RF4	3	Ca. scorpionfish	Muscle	Total DDT		4.7	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total DDT		10.1	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total PCB		0.7	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total PCB		0.5	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Total Solids		20.9	wt%	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc		3.5	mg/kg	0.049
SD15	1	Hornyhead turbot	Liver	Aluminum		0.888	mg/kg	0.583
SD15	1	Hornyhead turbot	Liver	Arsenic		8.47	mg/kg	0.375
SD15	1	Hornyhead turbot	Liver	Barium		0.026	mg/kg	0.007
SD15	1	Hornyhead turbot	Liver	Cadmium		2.22	mg/kg	0.029
SD15	1	Hornyhead turbot	Liver	Chromium		0.188	mg/kg	0.08
SD15	1	Hornyhead turbot	Liver	Copper		5.68	mg/kg	0.068
SD15	1	Hornyhead turbot	Liver	Hexachlorobenzene	E	0.8	ug/kg	
SD15	1	Hornyhead turbot	Liver	Iron		53.5	mg/kg	0.096
SD15	1	Hornyhead turbot	Liver	Lipids		12.1	wt%	0.005
SD15	1	Hornyhead turbot	Liver	Manganese		1.38	mg/kg	0.007
SD15	1	Hornyhead turbot	Liver	Mercury		0.065	mg/kg	0.03
SD15	1	Hornyhead turbot	Liver	p,p-DDD	E	1.6	ug/kg	
SD15	1	Hornyhead turbot	Liver	p,p-DDE		80	ug/kg	13.3
SD15	1	Hornyhead turbot	Liver	p,-p-DDMU	E	3.2	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 101	E	2	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 118	E	2.3	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 153/168	E	5.8	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 187	E	2.6	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 99	E	1.6	ug/kg	
SD15	1	Hornyhead turbot	Liver	Selenium		0.737	mg/kg	0.06
SD15	1	Hornyhead turbot	Liver	Silver		0.095	mg/kg	0.057
SD15	1	Hornyhead turbot	Liver	Tin		0.575	mg/kg	0.24
SD15	1	Hornyhead turbot	Liver	Total DDT		81.6	ug/kg	

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD15	1	Hornyhead turbot	Liver	Total PCB		14.3	ug/kg	
SD15	1	Hornyhead turbot	Liver	Total Solids		31.6	wt%	0.4
SD15	1	Hornyhead turbot	Liver	Zinc		60.1	mg/kg	0.049
SD15	2	Ca. scorpionfish	Liver	Aluminum		3.78	mg/kg	0.583
SD15	2	Ca. scorpionfish	Liver	Arsenic		0.77	mg/kg	0.375
SD15	2	Ca. scorpionfish	Liver	Barium		0.038	mg/kg	0.007
SD15	2	Ca. scorpionfish	Liver	Cadmium		2.34	mg/kg	0.029
SD15	2	Ca. scorpionfish	Liver	Chromium		0.264	mg/kg	0.08
SD15	2	Ca. scorpionfish	Liver	Copper		15.5	mg/kg	0.068
SD15	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Iron		146	mg/kg	0.096
SD15	2	Ca. scorpionfish	Liver	Lipids		16.4	wt%	0.005
SD15	2	Ca. scorpionfish	Liver	Manganese		0.526	mg/kg	0.007
SD15	2	Ca. scorpionfish	Liver	Mercury		0.052	mg/kg	0.03
SD15	2	Ca. scorpionfish	Liver	p,p-DDD	E	3.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	p,p-DDE		190	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	p,-p-DDMU	E	3.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 101	E	4.9	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 105	E	2.4	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 118	E	7.6	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 128	E	3.1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 138	E	10	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 153/168		17	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	PCB 180	E	8.9	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 183	E	2.6	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 187	E	9.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 194	E	1.6	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 206	E	1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 49	E	1.1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 66	E	1.4	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 70	E	0.8	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 74	E	0.8	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 99	E	4.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Selenium		1.2	mg/kg	0.06
SD15	2	Ca. scorpionfish	Liver	Silver		0.315	mg/kg	0.057
SD15	2	Ca. scorpionfish	Liver	Tin		0.52	mg/kg	0.24
SD15	2	Ca. scorpionfish	Liver	Total DDT		193.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Total PCB		77.6	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Total Solids		39	wt%	0.4
SD15	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	3.8	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Zinc		86.5	mg/kg	0.049
SD15	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	2.9	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Aluminum		4.52	mg/kg	0.583
SD15	3	Ca. scorpionfish	Liver	Arsenic		0.792	mg/kg	0.375
SD15	3	Ca. scorpionfish	Liver	Barium		0.037	mg/kg	0.007
SD15	3	Ca. scorpionfish	Liver	Cadmium		2.17	mg/kg	0.029
SD15	3	Ca. scorpionfish	Liver	Chromium		0.228	mg/kg	0.08
SD15	3	Ca. scorpionfish	Liver	Copper		15.5	mg/kg	0.068
SD15	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.1	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Iron		72.8	mg/kg	0.096
SD15	3	Ca. scorpionfish	Liver	Lipids		20.3	wt%	0.005
SD15	3	Ca. scorpionfish	Liver	Manganese		0.514	mg/kg	0.007
SD15	3	Ca. scorpionfish	Liver	Mercury		0.14	mg/kg	0.03
SD15	3	Ca. scorpionfish	Liver	o,p-DDE	E	1.9	ug/kg	

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD15	3	Ca. scorpionfish	Liver	p,p-DDD	E	11	ug/kg	
SD15	3	Ca. scorpionfish	Liver	p,p-DDE		450	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	p,-p-DDMU	E	8.2	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 101		15	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 105	E	7.1	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 110	E	8.7	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 118		26	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 128	E	7.6	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 138		35	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 149	E	7.7	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 151	E	4.6	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 153/168		54	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 156	E	3.2	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 158	E	2.3	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 167	E	1.8	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 170	E	6.6	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 177	E	5.2	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 180		21	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 183	E	6	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 187		23	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 194	E	3.2	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 201	E	4.5	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 206	E	1.7	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 49	E	2.4	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 66	E	4.9	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 70	E	0.6	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 74	E	2.7	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 87	E	3.4	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 99		16	ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	Selenium		0.82	mg/kg	0.06
SD15	3	Ca. scorpionfish	Liver	Silver		0.218	mg/kg	0.057
SD15	3	Ca. scorpionfish	Liver	Tin		0.586	mg/kg	0.24
SD15	3	Ca. scorpionfish	Liver	Total DDT		462.9	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Total PCB		274.2	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Total Solids		43.2	wt%	0.4
SD15	3	Ca. scorpionfish	Liver	Trans Nonachlor	E	6.3	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Zinc		63.8	mg/kg	0.049
SD16	1	Hornyhead turbot	Liver	Aluminum		3.01	mg/kg	0.583
SD16	1	Hornyhead turbot	Liver	Arsenic		1.74	mg/kg	0.375
SD16	1	Hornyhead turbot	Liver	Barium		0.029	mg/kg	0.007
SD16	1	Hornyhead turbot	Liver	Cadmium		4.08	mg/kg	0.029
SD16	1	Hornyhead turbot	Liver	Chromium		0.296	mg/kg	0.08
SD16	1	Hornyhead turbot	Liver	Copper		5.29	mg/kg	0.068
SD16	1	Hornyhead turbot	Liver	Hexachlorobenzene	E	1.2	ug/kg	
SD16	1	Hornyhead turbot	Liver	Iron		28.9	mg/kg	0.096
SD16	1	Hornyhead turbot	Liver	Lipids		8.37	wt%	0.005
SD16	1	Hornyhead turbot	Liver	Manganese		1.07	mg/kg	0.007
SD16	1	Hornyhead turbot	Liver	Mercury		0.083	mg/kg	0.03
SD16	1	Hornyhead turbot	Liver	o,p-DDE	E	1.9	ug/kg	
SD16	1	Hornyhead turbot	Liver	p,p-DDD	E	4.1	ug/kg	
SD16	1	Hornyhead turbot	Liver	p,p-DDE		120	ug/kg	13.3
SD16	1	Hornyhead turbot	Liver	p,-p-DDMU	E	6.9	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 101	E	1.8	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 118	E	3.9	ug/kg	

Appendix D.3 *continued*

October 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	1	Hornyhead turbot	Liver	PCB 138	E	6.3	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 153/168	E	8.8	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 180	E	4.7	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 187	E	4.7	ug/kg	
SD16	1	Hornyhead turbot	Liver	PCB 99	E	2.4	ug/kg	
SD16	1	Hornyhead turbot	Liver	Selenium		0.682	mg/kg	0.06
SD16	1	Hornyhead turbot	Liver	Silver		0.422	mg/kg	0.057
SD16	1	Hornyhead turbot	Liver	Tin		0.389	mg/kg	0.24
SD16	1	Longfin sanddab	Liver	Total DDT		412.7	ug/kg	
SD16	1	Hornyhead turbot	Liver	Total DDT		126	ug/kg	
SD16	1	Longfin sanddab	Liver	Total PCB		185.1	ug/kg	
SD16	1	Hornyhead turbot	Liver	Total PCB		32.6	ug/kg	
SD16	1	Hornyhead turbot	Liver	Total Solids		30	wt%	0.4
SD16	1	Hornyhead turbot	Liver	Zinc		50.3	mg/kg	0.049
SD16	2	Hornyhead turbot	Liver	Aluminum		4.35	mg/kg	0.583
SD16	2	Hornyhead turbot	Liver	Arsenic		1.71	mg/kg	0.375
SD16	2	Hornyhead turbot	Liver	Barium		0.036	mg/kg	0.007
SD16	2	Hornyhead turbot	Liver	Cadmium		5.36	mg/kg	0.029
SD16	2	Hornyhead turbot	Liver	Chromium		0.25	mg/kg	0.08
SD16	2	Hornyhead turbot	Liver	Copper		3.42	mg/kg	0.068
SD16	2	Hornyhead turbot	Liver	Iron		33.1	mg/kg	0.096
SD16	2	Hornyhead turbot	Liver	Lipids		13.3	wt%	0.005
SD16	2	Hornyhead turbot	Liver	Manganese		0.917	mg/kg	0.007
SD16	2	Hornyhead turbot	Liver	Mercury		0.109	mg/kg	0.03
SD16	2	Hornyhead turbot	Liver	p,p-DDD	E	5.2	ug/kg	
SD16	2	Hornyhead turbot	Liver	p,p-DDE		180	ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	p,-p-DDMU	E	7.9	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 101	E	1.9	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 105	E	1.1	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 118	E	4.7	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 138	E	9.5	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 153/168	E	12	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 180	E	7.2	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 187	E	7	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 66	E	1.5	ug/kg	
SD16	2	Hornyhead turbot	Liver	Selenium		1.05	mg/kg	0.06
SD16	2	Hornyhead turbot	Liver	Silver		0.487	mg/kg	0.057
SD16	2	Hornyhead turbot	Liver	Tin		0.475	mg/kg	0.24
SD16	2	Ca. scorpionfish	Liver	Total DDT		624.7	ug/kg	
SD16	2	Hornyhead turbot	Liver	Total DDT		185.2	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Total PCB		276.2	ug/kg	
SD16	2	Hornyhead turbot	Liver	Total PCB		44.9	ug/kg	
SD16	2	Hornyhead turbot	Liver	Total Solids		32.1	wt%	0.4
SD16	2	Hornyhead turbot	Liver	Zinc		48.3	mg/kg	0.049
SD16	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	10	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Aluminum		4.45	mg/kg	0.583
SD16	3	Ca. scorpionfish	Liver	Arsenic		0.551	mg/kg	0.375
SD16	3	Ca. scorpionfish	Liver	Barium		0.035	mg/kg	0.007
SD16	3	Ca. scorpionfish	Liver	Cadmium		3.07	mg/kg	0.029
SD16	3	Ca. scorpionfish	Liver	Chromium		0.233	mg/kg	0.08
SD16	3	Ca. scorpionfish	Liver	Cis Nonachlor	E	9.6	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Copper		23.5	mg/kg	0.068
SD16	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	2.8	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Iron		105	mg/kg	0.096

Appendix D.3 *continued*

October 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	3	Ca. scorpionfish	Liver	Lipids		22.1	wt%	0.005
SD16	3	Ca. scorpionfish	Liver	Manganese		0.535	mg/kg	0.007
SD16	3	Ca. scorpionfish	Liver	Mercury		0.441	mg/kg	0.03
SD16	3	Ca. scorpionfish	Liver	o,p-DDE		50	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	o,p-DDT	E	1.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	p,p-DDD		330	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,p-DDE		14400	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,-p-DDMU		490	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,p-DDT		27	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 101		88	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 105		43	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 110		57	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 114	E	3.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 118		130	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 119	E	3.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 123	E	12	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 128		25	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 138		110	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 149		31	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 151		17	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 153/168		160	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 156	E	13	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 157	E	3.1	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 158	E	11	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 167	E	6.7	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 170		22	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 177		16	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 180		72	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 183		18	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 187		57	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 194	E	10	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 201		18	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 206	E	5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 28	E	5.6	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 44	E	9.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 49		20	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 52		28	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 66		48	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 70	E	6.4	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 74		32	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 87		29	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 99		65	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	Selenium		0.855	mg/kg	0.06
SD16	3	Ca. scorpionfish	Liver	Silver		0.313	mg/kg	0.057
SD16	3	Ca. scorpionfish	Liver	Tin		0.524	mg/kg	0.24
SD16	3	Ca. scorpionfish	Liver	Total DDT		14808.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Total PCB		1175.1	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Total Solids		38.3	wt%	0.4
SD16	3	Ca. scorpionfish	Liver	Trans Nonachlor		27	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	Zinc		92.3	mg/kg	0.049
SD17	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	5.3	ug/kg	
SD17	1	Longfin sanddab	Liver	Aluminum		10.3	mg/kg	0.583
SD17	1	Longfin sanddab	Liver	Arsenic		3.54	mg/kg	0.375
SD17	1	Longfin sanddab	Liver	Barium		0.073	mg/kg	0.007

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	1	Longfin sanddab	Liver	Cadmium		2.15	mg/kg	0.029
SD17	1	Longfin sanddab	Liver	Chromium		0.35	mg/kg	0.08
SD17	1	Longfin sanddab	Liver	Cis Nonachlor	E	6.3	ug/kg	
SD17	1	Longfin sanddab	Liver	Copper		3.57	mg/kg	0.068
SD17	1	Longfin sanddab	Liver	Hexachlorobenzene	E	2.2	ug/kg	
SD17	1	Longfin sanddab	Liver	Iron		69.9	mg/kg	0.096
SD17	1	Longfin sanddab	Liver	Lipids		43.1	wt%	0.005
SD17	1	Longfin sanddab	Liver	Manganese		1.05	mg/kg	0.007
SD17	1	Longfin sanddab	Liver	Mercury		0.044	mg/kg	0.03
SD17	1	Longfin sanddab	Liver	o,p-DDD	E	1.1	ug/kg	
SD17	1	Longfin sanddab	Liver	o,p-DDE	E	8.8	ug/kg	
SD17	1	Longfin sanddab	Liver	o,p-DDT	E	1.9	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDD	E	13	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDE		900	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,-p-DDMU		22	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDT		17	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 101	E	6.3	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 105	E	6.7	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 110	E	3.7	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 118		25	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 123	E	2.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 128	E	8.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 138		55	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 149	E	7.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 151	E	6.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 153/168		96	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 156	E	4.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 158	E	3.4	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 167	E	2.7	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 170		18	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 177	E	7.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 180		52	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 183	E	13	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 187		50	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 194	E	10	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 201	E	12	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 206	E	3.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 66	E	2.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 74	E	1.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 99		15	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	Selenium		0.632	mg/kg	0.06
SD17	1	Longfin sanddab	Liver	Silver		0.075	mg/kg	0.057
SD17	1	Longfin sanddab	Liver	Tin		0.611	mg/kg	0.24
SD17	1	Longfin sanddab	Liver	Total DDT		745.8	ug/kg	
SD17	1	Longfin sanddab	Liver	Total DDT		941.8	ug/kg	
SD17	1	Longfin sanddab	Liver	Total PCB		263.8	ug/kg	
SD17	1	Longfin sanddab	Liver	Total PCB		415.7	ug/kg	
SD17	1	Longfin sanddab	Liver	Total Solids		52.6	wt%	0.4
SD17	1	Longfin sanddab	Liver	Trans Nonachlor	E	10	ug/kg	
SD17	1	Longfin sanddab	Liver	Zinc		20	mg/kg	0.049
SD17	2	Hornyhead turbot	Liver	Aluminum		3.15	mg/kg	0.583
SD17	2	Hornyhead turbot	Liver	Arsenic		1.61	mg/kg	0.375
SD17	2	Hornyhead turbot	Liver	Barium		0.029	mg/kg	0.007
SD17	2	Hornyhead turbot	Liver	Cadmium		2.84	mg/kg	0.029

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	2	Hornyhead turbot	Liver	Chromium		0.192	mg/kg	0.08
SD17	2	Hornyhead turbot	Liver	Copper		2.49	mg/kg	0.068
SD17	2	Hornyhead turbot	Liver	Iron		30.8	mg/kg	0.096
SD17	2	Hornyhead turbot	Liver	Lipids		12.1	wt%	0.005
SD17	2	Hornyhead turbot	Liver	Manganese		1.05	mg/kg	0.007
SD17	2	Hornyhead turbot	Liver	Mercury		0.072	mg/kg	0.03
SD17	2	Hornyhead turbot	Liver	p,p-DDD	E	6.1	ug/kg	
SD17	2	Hornyhead turbot	Liver	p,p-DDE		190	ug/kg	13.3
SD17	2	Hornyhead turbot	Liver	p,-p-DDMU	E	10	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 101	E	2.5	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 138	E	8.5	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 153/168	E	11	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 180	E	6.7	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 187	E	6.4	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 194	E	1.3	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 206	E	1	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 66	E	1.2	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 99	E	3	ug/kg	
SD17	2	Hornyhead turbot	Liver	Selenium		0.504	mg/kg	0.06
SD17	2	Hornyhead turbot	Liver	Silver		0.079	mg/kg	0.057
SD17	2	Hornyhead turbot	Liver	Tin		0.272	mg/kg	0.24
SD17	2	PACIFIC SANDDAB	Liver	Total DDT		531.7	ug/kg	
SD17	2	Hornyhead turbot	Liver	Total DDT		196.1	ug/kg	
SD17	2	PACIFIC SANDDAB	Liver	Total PCB		225.6	ug/kg	
SD17	2	Hornyhead turbot	Liver	Total PCB		41.6	ug/kg	
SD17	2	Hornyhead turbot	Liver	Total Solids		29.3	wt%	0.4
SD17	2	Hornyhead turbot	Liver	Zinc		48	mg/kg	0.049
SD17	3	Hornyhead turbot	Liver	2,6-dimethylnaphthalene		104	ug/kg	20.7
SD17	3	Hornyhead turbot	Liver	Aluminum		3.59	mg/kg	0.583
SD17	3	Hornyhead turbot	Liver	Arsenic		2.34	mg/kg	0.375
SD17	3	Hornyhead turbot	Liver	Barium		0.036	mg/kg	0.007
SD17	3	Hornyhead turbot	Liver	Cadmium		3.14	mg/kg	0.029
SD17	3	Hornyhead turbot	Liver	Chromium		0.234	mg/kg	0.08
SD17	3	Hornyhead turbot	Liver	Copper		4.82	mg/kg	0.068
SD17	3	Hornyhead turbot	Liver	Iron		37.8	mg/kg	0.096
SD17	3	Hornyhead turbot	Liver	Lipids		13	wt%	0.005
SD17	3	Hornyhead turbot	Liver	Manganese		0.745	mg/kg	0.007
SD17	3	Hornyhead turbot	Liver	Mercury		0.068	mg/kg	0.03
SD17	3	Hornyhead turbot	Liver	p,p-DDD	E	5.2	ug/kg	
SD17	3	Hornyhead turbot	Liver	p,p-DDE		140	ug/kg	13.3
SD17	3	Hornyhead turbot	Liver	p,-p-DDMU	E	6.7	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 101	E	2.3	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 118	E	3.3	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 138	E	7	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 153/168	E	8	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 180	E	5.4	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 187	E	5.8	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 66	E	0.9	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 99	E	2.6	ug/kg	
SD17	3	Hornyhead turbot	Liver	Selenium		0.692	mg/kg	0.06
SD17	3	Hornyhead turbot	Liver	Silver		0.09	mg/kg	0.057
SD17	3	Hornyhead turbot	Liver	Tin		0.395	mg/kg	0.24
SD17	3	Ca. scorpionfish	Liver	Total DDT		1538.65	ug/kg	

Appendix D.3 *continued*

October 2004

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	3	Hornyhead turbot	Liver	Total DDT		145.2	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Total PCB		288.45	ug/kg	
SD17	3	Hornyhead turbot	Liver	Total PCB		35.3	ug/kg	
SD17	3	Hornyhead turbot	Liver	Total Solids		30	wt%	0.4
SD17	3	Hornyhead turbot	Liver	Zinc		48.4	mg/kg	0.049
SD18	1	Longfin sanddab	Liver	Aluminum		4.75	mg/kg	0.583
SD18	1	Longfin sanddab	Liver	Arsenic		8.07	mg/kg	0.375
SD18	1	Longfin sanddab	Liver	Barium		0.045	mg/kg	0.007
SD18	1	Longfin sanddab	Liver	Cadmium		2.6	mg/kg	0.029
SD18	1	Longfin sanddab	Liver	Chromium		0.284	mg/kg	0.08
SD18	1	Longfin sanddab	Liver	Copper		4.64	mg/kg	0.068
SD18	1	Longfin sanddab	Liver	Hexachlorobenzene	E	1.3	ug/kg	
SD18	1	Longfin sanddab	Liver	Iron		89.9	mg/kg	0.096
SD18	1	Longfin sanddab	Liver	Lipids		22.8	wt%	0.005
SD18	1	Longfin sanddab	Liver	Manganese		1.33	mg/kg	0.007
SD18	1	Longfin sanddab	Liver	Mercury		0.118	mg/kg	0.03
SD18	1	Longfin sanddab	Liver	o,p-DDD	E	0.7	ug/kg	
SD18	1	Longfin sanddab	Liver	o,p-DDE	E	3.9	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDD	E	8.3	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDE		380	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	p,-p-DDMU	E	12	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDT	E	6.6	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 101	E	4.6	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 105	E	3.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 110	E	2.6	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 118	E	11	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 128	E	3.9	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 138		20	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 149	E	4.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 151	E	2.6	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 153/168		33	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 158	E	1.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 170	E	4.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 180		18	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 183	E	4.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 187		18	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 194	E	3.4	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 201	E	5.7	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 206	E	1.4	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 66	E	2.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 74	E	1	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 99	E	7	ug/kg	
SD18	1	Longfin sanddab	Liver	Selenium		0.914	mg/kg	0.06
SD18	1	Longfin sanddab	Liver	Silver		0.087	mg/kg	0.057
SD18	1	Longfin sanddab	Liver	Tin		0.336	mg/kg	0.24
SD18	1	Longfin sanddab	Liver	Total DDT		1170.8	ug/kg	
SD18	1	Longfin sanddab	Liver	Total DDT		399.5	ug/kg	
SD18	1	Longfin sanddab	Liver	Total PCB		664.5	ug/kg	
SD18	1	Longfin sanddab	Liver	Total PCB		152.4	ug/kg	
SD18	1	Longfin sanddab	Liver	Total Solids		43.8	wt%	0.4
SD18	1	Longfin sanddab	Liver	Zinc		20.6	mg/kg	0.049
SD18	2	Hornyhead turbot	Liver	Aluminum		2.5	mg/kg	0.583
SD18	2	Hornyhead turbot	Liver	Arsenic		2.66	mg/kg	0.375
SD18	2	Hornyhead turbot	Liver	Barium		0.027	mg/kg	0.007

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	2	Hornyhead turbot	Liver	Cadmium		4.72	mg/kg	0.029
SD18	2	Hornyhead turbot	Liver	Chromium		0.216	mg/kg	0.08
SD18	2	Hornyhead turbot	Liver	Copper		4.07	mg/kg	0.068
SD18	2	Hornyhead turbot	Liver	Iron		38.8	mg/kg	0.096
SD18	2	Hornyhead turbot	Liver	Lipids		11.1	wt%	0.005
SD18	2	Hornyhead turbot	Liver	Manganese		0.879	mg/kg	0.007
SD18	2	Hornyhead turbot	Liver	Mercury		0.128	mg/kg	0.03
SD18	2	Hornyhead turbot	Liver	o,p-DDE	E	1.9	ug/kg	
SD18	2	Hornyhead turbot	Liver	p,p-DDD	E	5.3	ug/kg	
SD18	2	Hornyhead turbot	Liver	p,p-DDE		190	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	p,-p-DDMU	E	11	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 101	E	2.6	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 118	E	4.1	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 138	E	8.4	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 153/168	E	11	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 180	E	6.9	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 187	E	6.4	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 206	E	1	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 66	E	1.3	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 74	E	0.8	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 99	E	13.3	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	Selenium		0.736	mg/kg	0.06
SD18	2	Hornyhead turbot	Liver	Silver		0.126	mg/kg	0.057
SD18	2	Hornyhead turbot	Liver	Tin		0.281	mg/kg	0.24
SD18	2	Longfin sanddab	Liver	Total DDT		973.4	ug/kg	
SD18	2	Hornyhead turbot	Liver	Total DDT		197.2	ug/kg	
SD18	2	Longfin sanddab	Liver	Total PCB		369.1	ug/kg	
SD18	2	Hornyhead turbot	Liver	Total PCB		55.8	ug/kg	
SD18	2	Hornyhead turbot	Liver	Total Solids		26.7	wt%	0.4
SD18	2	Hornyhead turbot	Liver	Zinc		49.7	mg/kg	0.049
SD18	3	Hornyhead turbot	Liver	Aluminum		2.03	mg/kg	0.583
SD18	3	Hornyhead turbot	Liver	Arsenic		2.78	mg/kg	0.375
SD18	3	Hornyhead turbot	Liver	Barium		0.029	mg/kg	0.007
SD18	3	Hornyhead turbot	Liver	Cadmium		4.34	mg/kg	0.029
SD18	3	Hornyhead turbot	Liver	Chromium		0.23	mg/kg	0.08
SD18	3	Hornyhead turbot	Liver	Copper		7.85	mg/kg	0.068
SD18	3	Hornyhead turbot	Liver	Hexachlorobenzene	E	1.3	ug/kg	
SD18	3	Hornyhead turbot	Liver	Iron		29.8	mg/kg	0.096
SD18	3	Hornyhead turbot	Liver	Lipids		10.5	wt%	0.005
SD18	3	Hornyhead turbot	Liver	Manganese		0.73	mg/kg	0.007
SD18	3	Hornyhead turbot	Liver	Mercury		0.063	mg/kg	0.03
SD18	3	Hornyhead turbot	Liver	o,p-DDD	E	1.55	ug/kg	
SD18	3	Hornyhead turbot	Liver	o,p-DDE	E	3.45	ug/kg	
SD18	3	Hornyhead turbot	Liver	p,p-DDD		21	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	p,p-DDE		300	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	p,-p-DDMU		17.5	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 101	E	3.85	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 105	E	2.05	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 110	E	1.2	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 118	E	6.35	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 128	<	13.3	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 138	E	12	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 149	E	3.2	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 151	E	1.75	ug/kg	

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	3	Hornyhead turbot	Liver	PCB 153/168		18	ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 180	E	12	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 183	E	4.25	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 187	E	11	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 194	E	2.35	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 206	E	1.3	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 66	E	1.9	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 70	E	1	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 74	E	1.15	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 99	E	5.15	ug/kg	
SD18	3	Hornyhead turbot	Liver	Selenium		0.479	mg/kg	0.06
SD18	3	Hornyhead turbot	Liver	Silver		0.202	mg/kg	0.057
SD18	3	Hornyhead turbot	Liver	Tin		0.451	mg/kg	0.24
SD18	3	Hornyhead turbot	Liver	Total DDT		158.3	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total DDT		326	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total PCB		26.6	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total PCB		101.8	ug/kg	
SD18	3	Hornyhead turbot	Liver	Total Solids		36	wt%	0.4
SD18	3	Hornyhead turbot	Liver	Zinc		53.9	mg/kg	0.049
SD19	1	Hornyhead turbot	Liver	Aluminum		2.58	mg/kg	0.583
SD19	1	Hornyhead turbot	Liver	Arsenic		1.85	mg/kg	0.375
SD19	1	Hornyhead turbot	Liver	Barium		0.032	mg/kg	0.007
SD19	1	Hornyhead turbot	Liver	Cadmium		4.75	mg/kg	0.029
SD19	1	Hornyhead turbot	Liver	Chromium		0.297	mg/kg	0.08
SD19	1	Hornyhead turbot	Liver	Copper		7.89	mg/kg	0.068
SD19	1	Hornyhead turbot	Liver	Iron		24.6	mg/kg	0.096
SD19	1	Hornyhead turbot	Liver	Lipids		7.59	wt%	0.005
SD19	1	Hornyhead turbot	Liver	Manganese		0.98	mg/kg	0.007
SD19	1	Hornyhead turbot	Liver	Mercury		0.116	mg/kg	0.03
SD19	1	Hornyhead turbot	Liver	p,p-DDD	E	3	ug/kg	
SD19	1	Hornyhead turbot	Liver	p,p-DDE		100	ug/kg	13.3
SD19	1	Hornyhead turbot	Liver	p,-p-DDMU	E	5.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 101	E	1.9	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 118	E	3.1	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 138	E	5.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 153/168	E	6.9	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 180	E	3.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 99	E	2.4	ug/kg	
SD19	1	Hornyhead turbot	Liver	Selenium		0.579	mg/kg	0.06
SD19	1	Hornyhead turbot	Liver	Silver		0.406	mg/kg	0.057
SD19	1	Hornyhead turbot	Liver	Tin		0.369	mg/kg	0.24
SD19	1	Hornyhead turbot	Liver	Total DDT		156.1	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total DDT		103	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total PCB		53.7	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total PCB		23.9	ug/kg	
SD19	1	Hornyhead turbot	Liver	Total Solids		35.3	wt%	0.4
SD19	1	Hornyhead turbot	Liver	Zinc		58.2	mg/kg	0.049
SD19	2	Hornyhead turbot	Liver	2,6-dimethylnaphthalene		113	ug/kg	20.7
SD19	2	Hornyhead turbot	Liver	Aluminum		3.78	mg/kg	0.583
SD19	2	Hornyhead turbot	Liver	Arsenic		1.62	mg/kg	0.375
SD19	2	Hornyhead turbot	Liver	Barium		0.036	mg/kg	0.007
SD19	2	Hornyhead turbot	Liver	Cadmium		3.27	mg/kg	0.029
SD19	2	Hornyhead turbot	Liver	Chromium		0.47	mg/kg	0.08

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	2	Hornyhead turbot	Liver	Copper		4.8	mg/kg	0.068
SD19	2	Hornyhead turbot	Liver	Hexachlorobenzene	E	1	ug/kg	
SD19	2	Hornyhead turbot	Liver	Iron		35.7	mg/kg	0.096
SD19	2	Hornyhead turbot	Liver	Lipids		12.9	wt%	0.005
SD19	2	Hornyhead turbot	Liver	Manganese		0.837	mg/kg	0.007
SD19	2	Hornyhead turbot	Liver	Mercury		0.061	mg/kg	0.03
SD19	2	Hornyhead turbot	Liver	o,p-DDE	E	3.4	ug/kg	
SD19	2	Hornyhead turbot	Liver	p,p-DDD	E	6.3	ug/kg	
SD19	2	Hornyhead turbot	Liver	p,p-DDE		210	ug/kg	13.3
SD19	2	Hornyhead turbot	Liver	p,-p-DDMU	E	9.7	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 101	E	2.4	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 105	E	1.3	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 118	E	4.5	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 138	E	8.5	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 153/168		14	ug/kg	13.3
SD19	2	Hornyhead turbot	Liver	PCB 180	E	7.1	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 183	E	1.9	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 187	E	7.8	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 194	E	1.7	ug/kg	
SD19	2	Hornyhead turbot	Liver	PCB 99	E	3.8	ug/kg	
SD19	2	Hornyhead turbot	Liver	Selenium		0.56	mg/kg	0.06
SD19	2	Hornyhead turbot	Liver	Silver		0.172	mg/kg	0.057
SD19	2	Hornyhead turbot	Liver	Tin		0.45	mg/kg	0.24
SD19	2	Hornyhead turbot	Liver	Total DDT		219.7	ug/kg	
SD19	2	Hornyhead turbot	Liver	Total PCB		53	ug/kg	
SD19	2	Hornyhead turbot	Liver	Total Solids		31.7	wt%	0.4
SD19	2	Hornyhead turbot	Liver	Zinc		42.2	mg/kg	0.049
SD20	1	Hornyhead turbot	Liver	Aluminum		4.78	mg/kg	0.583
SD20	1	Hornyhead turbot	Liver	Arsenic		0.949	mg/kg	0.375
SD20	1	Hornyhead turbot	Liver	Barium		0.034	mg/kg	0.007
SD20	1	Hornyhead turbot	Liver	Cadmium		4.31	mg/kg	0.029
SD20	1	Hornyhead turbot	Liver	Chromium		0.264	mg/kg	0.08
SD20	1	Hornyhead turbot	Liver	Copper		2.61	mg/kg	0.068
SD20	1	Hornyhead turbot	Liver	Iron		21.7	mg/kg	0.096
SD20	1	Hornyhead turbot	Liver	Lipids		16.4	wt%	0.005
SD20	1	Hornyhead turbot	Liver	Manganese		1.17	mg/kg	0.007
SD20	1	Hornyhead turbot	Liver	Mercury		0.092	mg/kg	0.03
SD20	1	Hornyhead turbot	Liver	p,p-DDE		51	ug/kg	13.3
SD20	1	Hornyhead turbot	Liver	p,-p-DDMU	E	3.2	ug/kg	
SD20	1	Hornyhead turbot	Liver	PCB 153/168	E	3.4	ug/kg	
SD20	1	Hornyhead turbot	Liver	Selenium		0.603	mg/kg	0.06
SD20	1	Hornyhead turbot	Liver	Tin		0.505	mg/kg	0.24
SD20	1	Longfin sanddab	Liver	Total DDT		543.6	ug/kg	
SD20	1	Hornyhead turbot	Liver	Total DDT		51	ug/kg	
SD20	1	Longfin sanddab	Liver	Total PCB		422.5	ug/kg	
SD20	1	Hornyhead turbot	Liver	Total PCB		3.4	ug/kg	
SD20	1	Hornyhead turbot	Liver	Total Solids		29.2	wt%	0.4
SD20	1	Hornyhead turbot	Liver	Zinc		50.2	mg/kg	0.049
SD20	2	Ca. scorpionfish	Liver	Aluminum		4.5	mg/kg	0.583
SD20	2	Ca. scorpionfish	Liver	Arsenic	<	0.375	mg/kg	0.375
SD20	2	Ca. scorpionfish	Liver	Barium		0.041	mg/kg	0.007
SD20	2	Ca. scorpionfish	Liver	Cadmium		3.01	mg/kg	0.029
SD20	2	Ca. scorpionfish	Liver	Chromium		0.275	mg/kg	0.08
SD20	2	Ca. scorpionfish	Liver	Copper		22.8	mg/kg	0.068

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	2.3	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Iron		130	mg/kg	0.096
SD20	2	Ca. scorpionfish	Liver	Lipids		6.35	wt%	0.005
SD20	2	Ca. scorpionfish	Liver	Manganese		0.698	mg/kg	0.007
SD20	2	Ca. scorpionfish	Liver	Mercury		0.124	mg/kg	0.03
SD20	2	Ca. scorpionfish	Liver	o,p-DDE	E	6	ug/kg	
SD20	2	Ca. scorpionfish	Liver	p,p-DDD	E	8.1	ug/kg	
SD20	2	Ca. scorpionfish	Liver	p,p-DDE		770	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	p,-p-DDMU		18	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	p,p-DDT	E	6.3	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 101		14	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 105	E	7.4	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 110	E	6	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 118		25	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 128	E	8.2	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 138		41	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 149	E	5.2	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 151	E	5.4	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 153/168		65	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 170	E	9.3	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 180		27	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 183	E	6.5	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 187		29	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 194	E	3.9	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 206	E	2.3	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 49	E	1.7	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 66	E	3.4	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 74	E	2	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 99		17	ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	Selenium		0.875	mg/kg	0.06
SD20	2	Ca. scorpionfish	Liver	Silver		0.715	mg/kg	0.057
SD20	2	Ca. scorpionfish	Liver	Tin		0.417	mg/kg	0.24
SD20	2	Hornyhead turbot	Liver	Total DDT		62	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Total DDT		790.4	ug/kg	
SD20	2	Hornyhead turbot	Liver	Total PCB		8.1	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Total PCB		279.3	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Total Solids		30.1	wt%	0.4
SD20	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	5.5	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Zinc		93.8	mg/kg	0.049
SD20	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	7.8	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Aluminum		6.24	mg/kg	0.583
SD20	3	Ca. scorpionfish	Liver	Antimony	<	0.478	mg/kg	0.478
SD20	3	Ca. scorpionfish	Liver	Arsenic		1.34	mg/kg	0.375
SD20	3	Ca. scorpionfish	Liver	Barium		0.048	mg/kg	0.007
SD20	3	Ca. scorpionfish	Liver	Cadmium		2.03	mg/kg	0.029
SD20	3	Ca. scorpionfish	Liver	Chromium		0.315	mg/kg	0.08
SD20	3	Ca. scorpionfish	Liver	Cis Nonachlor	E	5.8	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Copper		23.3	mg/kg	0.068
SD20	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	2.1	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Iron		185	mg/kg	0.096
SD20	3	Ca. scorpionfish	Liver	Lipids		24.1	wt%	0.005
SD20	3	Ca. scorpionfish	Liver	Manganese		0.538	mg/kg	0.007
SD20	3	Ca. scorpionfish	Liver	Mercury		0.114	mg/kg	0.03
SD20	3	Ca. scorpionfish	Liver	o,p-DDE		140	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	3	Ca. scorpionfish	Liver	o,p-DDT	E	1.7	ug/kg	
SD20	3	Ca. scorpionfish	Liver	p,p-DDD		390	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	p,p-DDE		10400	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	p,-p-DDMU		720	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	p,p-DDT		34	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 101		78	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 105		41	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 110		60	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 114	E	2.1	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 118		110	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 119	E	3.2	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 123	E	11	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 128		22	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 138		88	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 149		26	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 151		15	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 153/168		130	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 156	E	11	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 158	E	10	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 167	E	5.1	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 170		19	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 177		14	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 180		60	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 183		16	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 187		49	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 194	E	8.9	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 201	E	13	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 206	E	4.4	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 28	E	10	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 44		16	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 49		26	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 52		35	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 66		53	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 70		34	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 74		31	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 87		29	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 99		61	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	Selenium		0.686	mg/kg	0.06
SD20	3	Ca. scorpionfish	Liver	Silver		0.394	mg/kg	0.057
SD20	3	Ca. scorpionfish	Liver	Tin		0.74	mg/kg	0.24
SD20	3	Longfin sanddab	Liver	Total DDT		244.5	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Total DDT		10965.7	ug/kg	
SD20	3	Longfin sanddab	Liver	Total PCB		150.1	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Total PCB		1091.7	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Total Solids		55.5	wt%	0.4
SD20	3	Ca. scorpionfish	Liver	Trans Nonachlor		17	ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	Zinc		89.6	mg/kg	0.049
SD21	1	Hornyhead turbot	Liver	Aluminum		4.19	mg/kg	0.583
SD21	1	Hornyhead turbot	Liver	Arsenic		1.42	mg/kg	0.375
SD21	1	Hornyhead turbot	Liver	Barium		0.037	mg/kg	0.007
SD21	1	Hornyhead turbot	Liver	Cadmium		8.02	mg/kg	0.029
SD21	1	Hornyhead turbot	Liver	Chromium		0.287	mg/kg	0.08
SD21	1	Hornyhead turbot	Liver	Copper		4.59	mg/kg	0.068
SD21	1	Hornyhead turbot	Liver	Hexachlorobenzene	E	1	ug/kg	

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	1	Hornyhead turbot	Liver	Iron		41.2	mg/kg	0.096
SD21	1	Hornyhead turbot	Liver	Lipids		9.67	wt%	0.005
SD21	1	Hornyhead turbot	Liver	Manganese		0.893	mg/kg	0.007
SD21	1	Hornyhead turbot	Liver	Mercury		0.154	mg/kg	0.03
SD21	1	Hornyhead turbot	Liver	o,p-DDE	E	2.3	ug/kg	
SD21	1	Hornyhead turbot	Liver	p,p-DDD	E	11	ug/kg	
SD21	1	Hornyhead turbot	Liver	p,p-DDE		160	ug/kg	13.3
SD21	1	Hornyhead turbot	Liver	p,-p-DDMU	E	8.6	ug/kg	
SD21	1	Hornyhead turbot	Liver	p,p-DDT	E	10	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 101	E	2.4	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 105	E	1.8	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 118	E	6.7	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 128	E	1.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 138	E	12	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 149	E	2	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 153/168		17	ug/kg	13.3
SD21	1	Hornyhead turbot	Liver	PCB 180	E	8.5	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 183	E	3.2	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 187	E	11	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 194	E	2.4	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 206	E	1.8	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 66	E	1.2	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 74	E	0.7	ug/kg	
SD21	1	Hornyhead turbot	Liver	PCB 99	E	4	ug/kg	
SD21	1	Hornyhead turbot	Liver	Selenium		0.654	mg/kg	0.06
SD21	1	Hornyhead turbot	Liver	Silver		0.177	mg/kg	0.057
SD21	1	Hornyhead turbot	Liver	Tin		0.369	mg/kg	0.24
SD21	1	Hornyhead turbot	Liver	Total DDT		96.9	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total DDT		183.3	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total PCB		41	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total PCB		76.6	ug/kg	
SD21	1	Hornyhead turbot	Liver	Total Solids		31.9	wt%	0.4
SD21	1	Hornyhead turbot	Liver	Zinc		57.6	mg/kg	0.049
SD21	2	Hornyhead turbot	Liver	Aluminum		4.76	mg/kg	0.583
SD21	2	Hornyhead turbot	Liver	Arsenic		1.97	mg/kg	0.375
SD21	2	Hornyhead turbot	Liver	Barium		0.041	mg/kg	0.007
SD21	2	Hornyhead turbot	Liver	Cadmium		6.92	mg/kg	0.029
SD21	2	Hornyhead turbot	Liver	Chromium		0.386	mg/kg	0.08
SD21	2	Hornyhead turbot	Liver	Copper		7.98	mg/kg	0.068
SD21	2	Hornyhead turbot	Liver	Iron		29.6	mg/kg	0.096
SD21	2	Hornyhead turbot	Liver	Lipids		13.3	wt%	0.005
SD21	2	Hornyhead turbot	Liver	Manganese		1.28	mg/kg	0.007
SD21	2	Hornyhead turbot	Liver	Mercury		0.288	mg/kg	0.03
SD21	2	Hornyhead turbot	Liver	o,p-DDE	E	3.2	ug/kg	
SD21	2	Hornyhead turbot	Liver	o,p-DDT	E	3.8	ug/kg	
SD21	2	Hornyhead turbot	Liver	p,p-DDD		36	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	p,p-DDE		210	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	p,-p-DDMU	E	11	ug/kg	
SD21	2	Hornyhead turbot	Liver	p,p-DDT		51	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	PCB 101	E	4.7	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 105	E	2.7	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 118	E	10	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 128	E	3	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 138		19	ug/kg	13.3

Appendix D.3 *continued*

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	2	Hornyhead turbot	Liver	PCB 149	E	3.3	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 153/168		29	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	PCB 170	E	5.1	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 180		15	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	PCB 183	E	4.4	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 187		18	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	PCB 194	E	3.6	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 206	E	2	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 49	E	1.5	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 66	E	2.2	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 70	E	0.7	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 74	E	1.1	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 99	E	7.5	ug/kg	
SD21	2	Hornyhead turbot	Liver	Selenium		0.417	mg/kg	0.06
SD21	2	Hornyhead turbot	Liver	Silver		0.21	mg/kg	0.057
SD21	2	Hornyhead turbot	Liver	Tin		0.416	mg/kg	0.24
SD21	2	Ca. scorpionfish	Liver	Total DDT		954.5	ug/kg	
SD21	2	Hornyhead turbot	Liver	Total DDT		304	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Total PCB		434.7	ug/kg	
SD21	2	Hornyhead turbot	Liver	Total PCB		132.8	ug/kg	
SD21	2	Hornyhead turbot	Liver	Total Solids		29.3	wt%	0.4
SD21	2	Hornyhead turbot	Liver	Zinc		57.4	mg/kg	0.049
SD21	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	3.5	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Aluminum		8.83	mg/kg	0.583
SD21	3	Ca. scorpionfish	Liver	Arsenic		0.724	mg/kg	0.375
SD21	3	Ca. scorpionfish	Liver	Barium		0.055	mg/kg	0.007
SD21	3	Ca. scorpionfish	Liver	Cadmium		3.62	mg/kg	0.029
SD21	3	Ca. scorpionfish	Liver	Chromium		0.423	mg/kg	0.08
SD21	3	Ca. scorpionfish	Liver	Copper		19.7	mg/kg	0.068
SD21	3	Ca. scorpionfish	Liver	Iron		241	mg/kg	0.096
SD21	3	Ca. scorpionfish	Liver	Lipids		19.1	wt%	0.005
SD21	3	Ca. scorpionfish	Liver	Manganese		0.667	mg/kg	0.007
SD21	3	Ca. scorpionfish	Liver	Mercury		0.232	mg/kg	0.03
SD21	3	Ca. scorpionfish	Liver	p,p-DDD	E	8.2	ug/kg	
SD21	3	Ca. scorpionfish	Liver	p,p-DDE		600	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	p,-p-DDMU	E	7.6	ug/kg	
SD21	3	Ca. scorpionfish	Liver	p,p-DDT	E	4.6	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 101	E	11	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 105	E	6.5	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 110	E	6.7	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 118		22	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 128	E	6.6	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 138		30	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 149	E	6	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 151	E	4.1	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 153/168		48	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 156	E	3.6	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 170	E	8	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 180		23	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 183	E	6.4	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 187		23	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 194	E	4.2	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 201	E	6.4	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 206	E	2.1	ug/kg	

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	3	Ca. scorpionfish	Liver	PCB 49	E	1.5	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 66	E	3.5	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 70	E	1.7	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 74	E	1.8	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 87	E	3.4	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 99	E	9.7	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Selenium		0.873	mg/kg	0.06
SD21	3	Ca. scorpionfish	Liver	Silver		0.44	mg/kg	0.057
SD21	3	Ca. scorpionfish	Liver	Tin		0.649	mg/kg	0.24
SD21	3	Longfin sanddab	Liver	Total DDT		405.1	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Total DDT		612.8	ug/kg	
SD21	3	Longfin sanddab	Liver	Total PCB		254.5	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Total PCB		239.2	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Total Solids		42.8	wt%	0.4
SD21	3	Ca. scorpionfish	Liver	Trans Nonachlor	E	11	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Zinc		104	mg/kg	0.049